JOURNAL OF

THE INSTITUTE OF PETROLEUM

FOUNDED 1913 + INCORPORATED 1914

Vol. 36 NOVEMBER 1950 No. 323

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Published by the Institute of Petroleum
Address: Manson House, 26 Portland Place, London, W.1
Telephone No.: LANgham 2250
Telegraphic Address: Instpetech, Westdo, London
Printed in Great Britain by Richard Clay and Company, Ltd., Bungay, Suffolk

Price 10s. 0d. Annual Sub. £4 14s. 6d. (Post Free)

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OXIDATION STABILITY OF TRANSFORMER OILS

By A. J. HAM (Fellow) * and C. N. THOMPSON (Associate Fellow)*

THE essential properties of a satisfactory transformer oil, which has to fulfil the double role of coolant and dielectric, are governed largely by various national specifications, and generally speaking, are as follows :—

(a) *Low viscosity.* This is vital, in order that the oil may dissipate, largely by a convection mechanism, the heat generated in the equipment. Oils of quite different types have been shown [1] to have thermal conductivities of the same order, and in any case, heat dissipation by conduction alone is probably of lesser importance. Thus the selection of suitable oil types, other than on a viscosity basis, would not be expected to facilitate heat transfer.

(b) *Low pour point.* Oils in transformers exposed to extreme cold must not solidify, otherwise they would cease to function as efficient coolants.

(c) *High flash point.* Fire and explosion are always potential hazards where hot petroleum oils are present in contact with electrical equipment, and a minimum flash point is stipulated in most specifications with the object of reducing this risk. Top oil temperatures in transformers are, however, appreciably lower than the flash point of any oil of the type normally used for insulation, and the differences in flash point of such oils are of little practical significance.

(d) *Low volatility.* Losses of oil by evaporation must be reduced to a minimum by selecting an oil having a low vapour pressure at the operating temperature of the equipment.

To a large extent the product must represent a compromise with regard to its physical properties, in that low viscosity and low pour point are associated with oils of low molecular weight, whereas the reverse is true of high flash point and low volatility.

(e) *Chemical purity.* The product must be free from corrosive, *e.g.*, acidic, components which would cause damage to the constructional materials present in a modern oil-filled transformer.

(f) *Electrical purity.* The oil must have a high dielectric strength, (*i.e.*, it must be free from traces of water, fibrous material, dust, etc.), in order that it may fulfil its dielectric function satisfactorily. The use of the D.C. resistivity and/or the power factor of the oil as a quality criterion has been suggested ; [2] although this may be a sound proposal from the theoretical point of view, practical problems arising from the sensitive and difficult nature of such measurements, and their interpretation, militate against their use as a specification requirement. The extreme sensitivity of measurements of surface [3] or dielectric properties of insulating oils in detecting small traces of deleterious polar contaminants, compared with the conventional physical and chemical tests, may be such that contamination below the limit of practical importance is given undue emphasis.

(g) *Oxidation stability.* It is necessary to ensure that properties (*a*) to

* Thornton Research Centre, "Shell" Refining and Marketing Co. Ltd.

(*f*) should remain as near constant as possible during service, otherwise the transformer may fail to function satisfactorily. Oxidation stability is of prime importance in that chemical and electrical purity become impaired largely as a result of oxidation processes. Transformer design is frequently such that, in operation, the oil is held at temperatures in the region of 60°–80° C, in contact with atmospheric oxygen, and also metals such as copper and iron which are active catalysts for oil oxidation. Constructional artifices are frequently used in an attempt to minimize or eliminate contact of the hot oil with air, catalytic metals, or both. In some transformers, particularly those of larger size, a " conservator " tank is arranged so that the expansion and contraction (" breathing ") of the main bulk of the hot oil may occur via a connexion between the large tank and an auxiliary tank containing relatively cold oil, only the latter being in direct contact with air. Metal surfaces are protected by paper, cotton, varnish, resins, paints, etc. The use of a thermosyphon, which permits circulation of the oil through a bed of active adsorbent, has been proposed for the continuous removal of oil-oxidation products, which are both inherently dangerous and also catalytic agents for further oxidation of the oil.

Although properties (*a*) to (*f*) can be controlled with relative ease by oil refiners, oxidation may result in profound changes in some of these properties during the course of time, as a consequence of which the oil ceases to fulfil either or both of its essential functions. As a broad generalization, it may be stated that, within limits of climatic requirements, oil properties (*a*) to (*g*) are controlled to specification figures on a national basis. Every national specification has its own oxidation test, and there are also other tests used by individual firms; these differ considerably one from another, and an oil which passes one will not necessarily pass another. It is difficult, almost impossible, for one oil to pass all tests.

Published Methods for the Evaluation of Oxidation Stability

It is generally accepted that the major final oxidation products of transformer oils are : (i) sludge, (ii) acids and carbon dioxide, and (iii) water. The precipitation of sludge in those parts of a transformer where good heat transfer by convection is important may result in reduced heat dissipation, the oil consequently becoming hotter, and therefore deteriorating at a greater rate. Thus more sludge is formed, and deterioration proceeds at an accelerating rate. Acidity development can give rise to serious corrosion problems, and may also cause the destruction or damage of the other insulating or protective materials. Water produced by oxidation reactions may become emulsified, especially in the presence of other oxidation products, promoting corrosion, etc., and will also reduce the dielectric strength of the oil. The use of desiccant breathers for the continuous removal of water (either from oxidation or from the atmosphere) is now widespread.

There has been much controversy in the past as to which oxidation product is the most undesirable; for the elimination of sludge the oil must either be refined again, or subjected to centrifuging, filtration, or other treatment *in situ*; re-treatment is also necessary to remove acidic com-

pounds, whereas water may be removed relatively simply without interfering with the operation of the equipment.

For control purposes, it is essential to have an oxidation test and desirable that such a test should :—

1. Simulate, as far as possible, the service conditions to which a transformer oil is subjected.
2. Yield repeatable and reproducible results (*e.g.*, acidity and sludge) within a reasonable space of time.

These two requirements are in conflict since, if service conditions were simulated faithfully, the test procedure would require an unreasonably long time for its completion. In general, therefore, laboratory tests of oil-oxidation stability are accelerated by choosing more severe reaction conditions than those obtaining in service.

This choice must be governed by the facts that if the reaction conditions are too drastic, or if all the contributing factors are not accelerated to the same relative degree, oxidation reactions may occur which bear little relation to those actually taking place under service conditions in transformers.

Table I summarizes many of the various national oxidation tests. It will be observed that most of these laboratory acceleration procedures are carried out for a fixed time, at the end of which the oxidized oil is subjected to an examination in order to determine the relative proportions of sludge, acidity, etc.

It is to be noted that although the average reaction temperature adopted in various countries is in the region of 120° C, the British test, and one or two others, are carried out at 150° C or higher. Over twenty years ago the first objections [11] were made to the choice of this relatively high temperature, and the view is now widely held that the reaction temperature of 150° C departs too much from that usually encountered in service. The sludges formed at this temperature are believed to be polymerized oxidation products of different type and molecular weight from those forming during service. Other criticisms have been raised more recently [14, 15] to a test temperature of 150° C. The proposed introduction of a limiting value for acidity, as well as for sludge, is considered to be an improvement in the B.S. 148 specification. Another significant feature of Table I is that in no test is the *rate* of the overall oxidation reaction determined. The nearest approach to a rate determination is the A.S.T.M. sludge method A, where an attempt has been made to assess not only the sludge formation but also the rate of increase of sludge, as in the Clark–Snyder sludge test.

It has become apparent in recent years that, with the advent of inhibited transformer oils, many of these tests would either fail to discriminate among different oils (*e.g.*, zero sludge value in the British test) or, in the case of tests having variable reaction times, would continue for an unduly long period. It is also equally apparent that a rapid laboratory evaluation procedure may deviate so widely in the reaction conditions employed from those existing in transformers that the results are not capable of reliable translation into terms of service performance of the oils in question.

TABLE I

Various Oxidation Procedures for the Evaluation of Transformer Oil Stability

Country.	Name of test and/or originator.	Reaction Conditions.					Criterion.	Remarks.	Reference.
		Type of system.	Vapour phase.	Catalyst.	Temp., °C.	Time, hr.			
Great Britain	British Standards Institution (Michie). B.S. 148/1933	Circulatory	Air (2 l/hr.) through sample	Copper	150	45	Sludge (% w) insoluble in petroleum spirit	Partial retention of products	4
U.S.A.	A.S.T.M. sludge test, method A	Circulatory	Air (0·5 l/hr) over sample	Copper	120	72 168 336	Sludge (%) at end of 3 test periods	Tentative method, not applicable to inhibited oils	5
U.S.A.	A.S.T.M. sludge test, method B	Diffusion, pressure	Oxygen 250 p.s.i.	None	140	24	Sludge (%)	Tentative method, not applicable to inhibited or "white" oils	5
U.S.A.	Snyder life test	Diffusion	Air (1 cu. ft/hr) over sample	None	120	Variable	Visible sludge in oil	—	6
U.S.A.	Clark–Snyder sludge test	Diffusion	Air (1·5–2 cu. ft/hr over sample	±Copper	120	Variable	Sludge (%) at several periods	Rate of sludge formation "not yet satisfactory for standardization"	7
Sweden	Sveriges standardiserings-kommission, S.E.N. 14–01/07, 1948 (Asea–Anderson)	Circulatory	Oxygen	Copper–iron	100	100	Sludge, acidity	10 Kv. applied electric field	9

Switzerland	Schweizerischer Elektrotechnischer Verein Nr. 124 (Brown-Boveri et cie). S.E.V. 124/1936.	Diffusion	Air	Copper beaker	110	72 168	Sludge, acidity, peroxides (as indicated by decrease in tensile strength of cotton insulation)	—	8, 10, 11
France	Matthis	Diffusion	Air	None	Variable, e.g. 170, 200	Variable, e.g. 5, 10	Time and temp. when sludge appears	—	12
Germany	Verband Deutscher Elektrotechniker. V.D.E. 0370/1936	Circulatory	Oxygen (through sample)	None	120	70	Kissling tar value	—	8
Germany	Evers-Schmidt (Siemens)	Diffusion	Oxygen	Iron, molybdenum silicon oxides	120 or 150	2 hr or more	Oxygen consumption	—	13
Belgium	Belgian Standards Association	Diffusion	Air	None	170	8	Visible sludge in oil	—	23
Czechoslovakia	C.S.N. Enc/1947	Circulatory	Oxygen	None	120	56	Tar value	Draft revision in course of preparation	24
France	U.S.E.	Diffusion	Air	None	150	125	Sludge (%)	—	25
U.S.S.R.	G.O.S.T.	Circulatory	Air	Copper-iron	140	14	Sludge (%), acidity, saponification value	—	26

Development of New Test Procedures

Having in mind the inadequacies of existing tests as outlined in the preceding paragraphs, attempts are being made to develop a graded series of test procedures, of varying degrees of acceleration, from a very rapid laboratory procedure to a much slower field trial in service transformers. Such a series, in which each test measures the *rate* of oxidation, would obviously supply adequate information regarding the service performance of oils, provided that reasonable correlation could be established at each stage and that it were possible to assess the relative proportions of deleterious oxidation products. In no case should the reaction temperature be greater than 120° C, and it is preferable that the slowest procedure should be carried out at a temperature in the neighbourhood of that obtaining in service (60°–80° C). The series of tests currently under evaluation is briefly indicated below; it should be made clear that such tests are in the developmental stage and are not at present being put forward individually as replacements for established procedures, as correlation with service performance has not yet been established.

(1) A rapid laboratory procedure has been developed, in which the rate of oxygen absorption is measured. This procedure utilizes a small oil sample, containing a soluble copper catalyst, and held under "static," *i.e.*, non-circulatory conditions, and a vapour phase of oxygen (see Fig. 1). The oxidation products are retained within the system, the apparatus being somewhat similar to that used by Gemant,[16] who carried out experiments at 145° C and 155° C using a very small volume of *air* above the oil, which was in contact with a copper catalyst. In the present work the oils have been examined for sludge and acidity at a level of deterioration corresponding to an oxygen absorption of 1000 ml oxygen per 100 g oil, whereas in Gemant's work, the oils were oxidized to a level of deterioration corresponding to a maximum volume contraction of only 10 ml/100 g oil. To date this procedure has proved to be particularly useful in comparing the oxidation stabilities of oils containing inhibitors.

(2) A second procedure in the series of tests at different rates of acceleration is carried out using the automatic circulatory apparatus shown in Fig. 2. A recording oxygen-absorption meter is incorporated, and this enables the oxidation-rate curve to be followed continuously up to a fixed oxygen consumption, independently of time. This refinement is necessary, for it may take over a hundred hours for the oxidation of an inhibited oil to proceed beyond the induction-period stage under these conditions. The apparatus used for this second stage of acceleration resembles that of Larsen and Reamer,[17] and will be described in more detail elsewhere, but the principle is essentially the same as that in the more rapid evaluation test, except in so far as (1) a less active catalyst is used, (2) pure oxygen is circulated throughout the system, and (3) all the more volatile oxidation products are collected and removed, while the less volatile products are retained in or returned to the reaction vessel, as is largely the case under service conditions.

(3) Another evaluation procedure is an accelerated field service test in small (1-kVA) transformer units.[18] Each unit (Fig. 3) is lagged and operated at *ca* 20 per cent overload, in order to facilitate the oxidation reaction by

increasing the temperature. Although the reaction would have been faster if free access of oxygen had been permitted, breathing was deliberately restricted in some cases in order that the effect of retaining the more volatile oxidation products (such as corrosive acids, etc.) could be determined. The units are installed in a transformer-testing laboratory, as shown in Fig. 4, and are run under " cycling " conditions,[19] being allowed to cool to laboratory temperature for one day in seven. It was established in the more rapid oxidation procedures that, once the oxidation of an oil has extended beyond the induction-period stage, then interruptions of the normal oxidation reactions (*e.g.*, by an overnight shutdown) result in a different

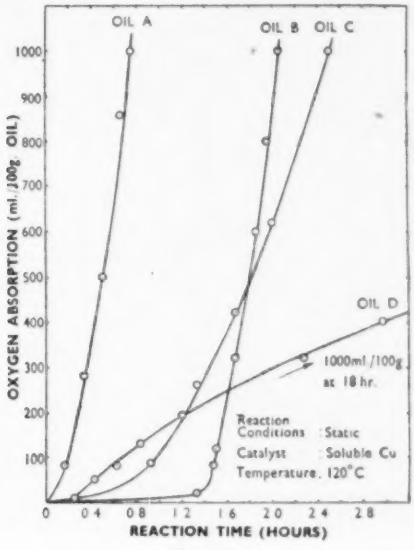

FIG. 6.

OXIDATION RATE CURVES FOR VARIOUS UNINHIBITED TRANSFORMER OILS AND RELATED PRODUCTS.

reaction velocity when the oxidation is allowed to resume. This is believed to be connected with the accumulation of peroxides at the lower temperatures; these compounds are potent oil-oxidation catalysts, being precursor materials for later degradation products from the chain reactions [20] which give rise to sludge, acidity, etc.

(4) A fourth stage of acceleration, viz., long-term tests in 50-kVA transformers (Fig. 5) under only slightly overload conditions, as well as full-scale field-service tests, should provide reliable indications of the service performance of various oils, and also may establish correlations with the other, more rapid, tests.

Oxidation-rate curves by the most rapid laboratory tests for transformer oils and related products are given in Fig. 6. It is at once apparent that the shapes of the rate curves (*e.g.*, for the four oils A, B, C, and D) are of prime importance in any evaluation of service performance. Any test which is run for a fixed time is capable of yielding misleading results

because of the fact that it ignores the possibility that oils can show oxidation-rate curves of widely different types. It can be seen from Fig. 6 that a fixed-time test procedure which terminates at a given point on the time axis will yield different relative results from another test at another reaction time, and it is quite conceivable that neither test will give results which are capable of predicting the true service performance of an oil.

If the oxidation tests shown in Fig. 6 were terminated at a time corresponding to 1·0 hours, then determinations of either sludge or acidity (or both) on the oxidized oils would class them in the following order of decreasing merit B, C, D, A, if it is assumed that the amounts of deleterious products

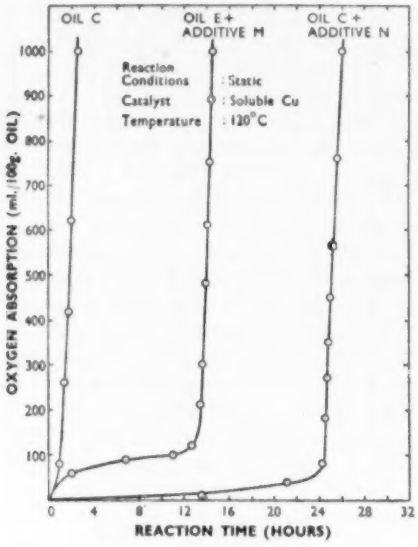

FIG. 7.

EFFECT OF ANTIOXIDANT ADDITIVES ON THE OXIDATION STABILITY OF TRANSFORMER OILS.

formed are proportional to the volume of oxygen absorbed by, and reacting with, the oils. This is because, whilst the oxidation of oil B has not proceeded beyond the induction-period stage, oil A has reacted with more than 1000 ml oxygen (per 100 g oil, ; at a later stage in the oxidation (say 2·0 hours), the oils, again in descending order of merit, would be D, C, B, A; a quite different state of affairs. Similar conclusions have also been reported by Anderson.[21] Furthermore, it is quite possible for the relative order of the reaction rates, as determined in the rapid static procedure at 120° C, to be quite different from those in service at lower temperatures such as 60° or 80° C. For this reason the results of a single test procedure at a fixed degree of acceleration should not be considered solely on their own merit, but also in conjunction with other tests at widely differing reaction rates at least until further correlation work has been carried out. The slower the oxidation reaction, the greater the resemblance to service conditions, and therefore the more desirable it is to study in such slower tests

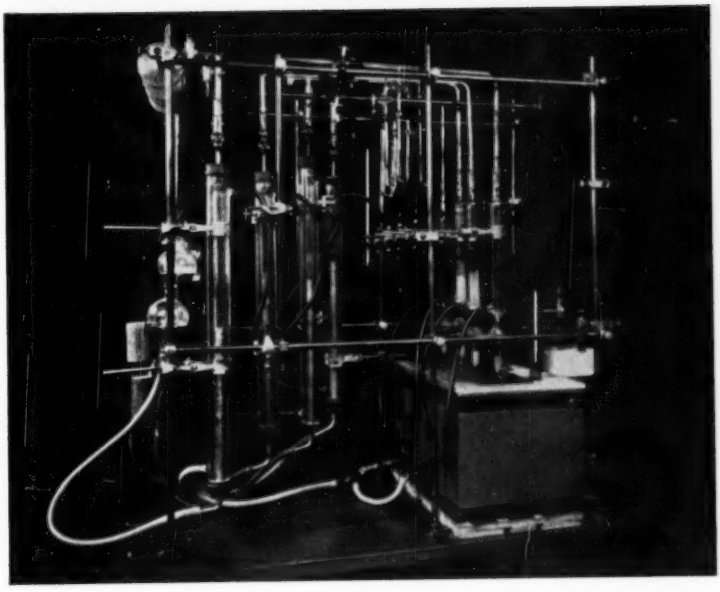

FIG. I.

STATIC OXIDATION APPARATUS.

To face p. 680

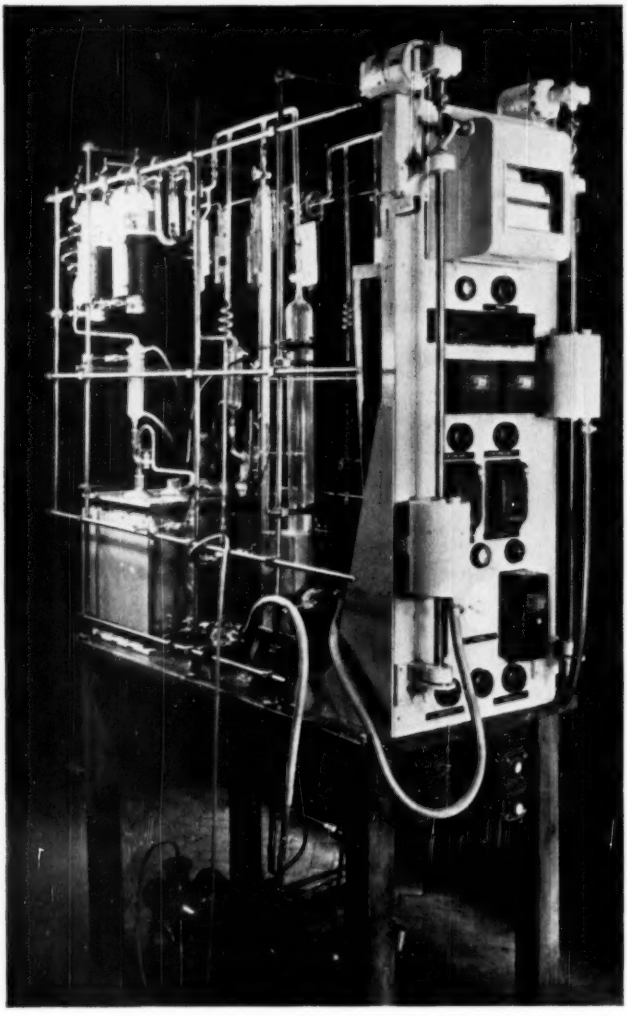

FIG. 2.

CIRCULATORY OXIDATION APPARATUS.

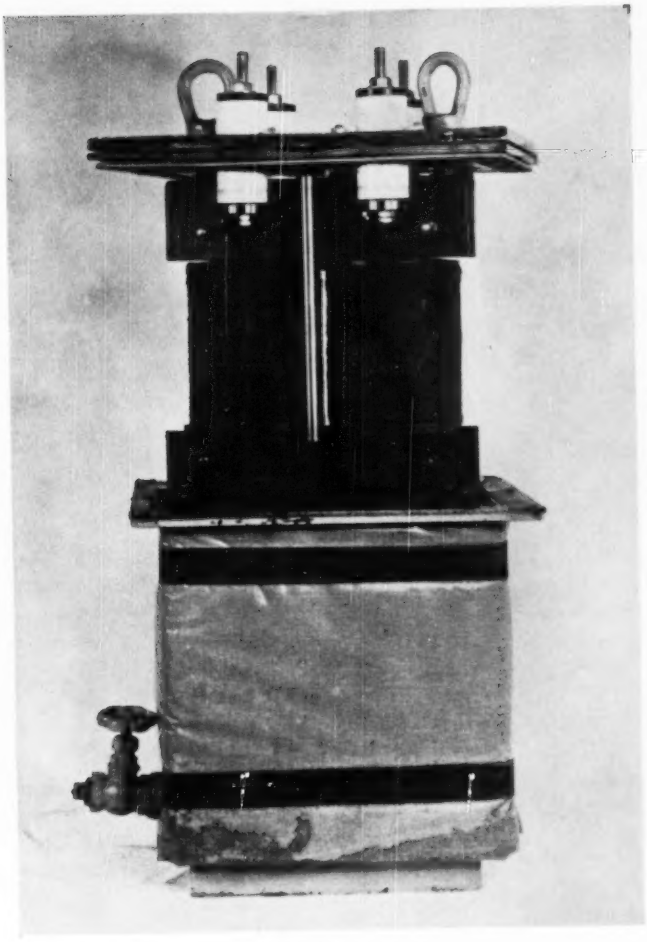

FIG. 3.

A 1-KVA. TEST TRANSFORMER, AFTER TEST, SHOWING CONDITION OF WINDING.

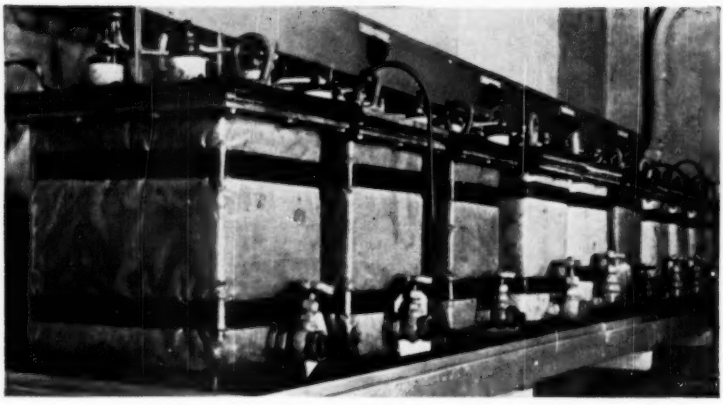

FIG. 4.
1-KVA. TEST TRANSFORMERS.

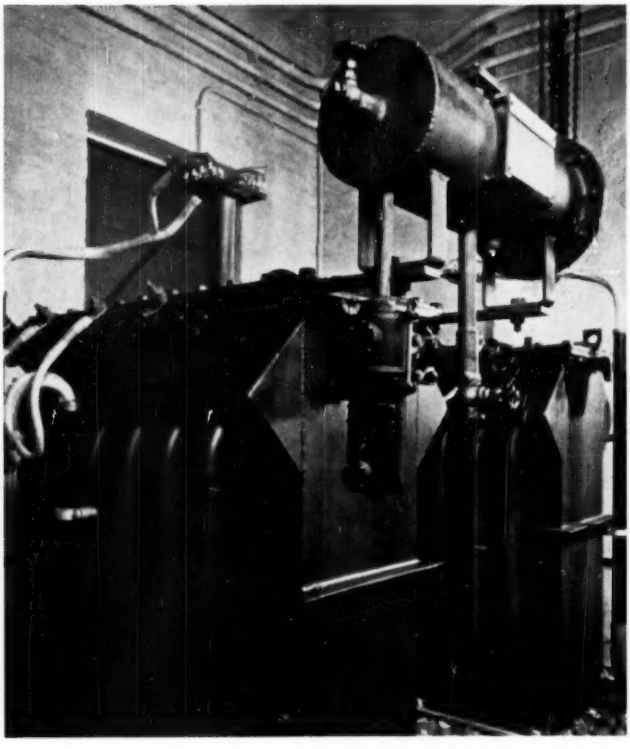

FIG. 5.
50-KVA. TEST TRANSFORMERS.

those various factors, such as transformer constructional materials and cycling operation, which are present in service.

The effect of the addition of an oxidation inhibitor to a conventional type of transformer oil is shown graphically in Fig. 7, approximately a ten-fold increase in stability being feasible, at least under laboratory conditions, with a product inhibited against oxidation. The function [22] of the antioxidant is merely to delay the onset of oxidation by interfering with the normal chain-reaction mechanism.[20] After an induction period, the duration of which depends not only on the oil but also on the type and amount of inhibitor, oxidation proceeds at the normal rate for the uninhibited oil.

Fig. 8 is a graph of the oxidation-rate curve for a conventional B.30 class

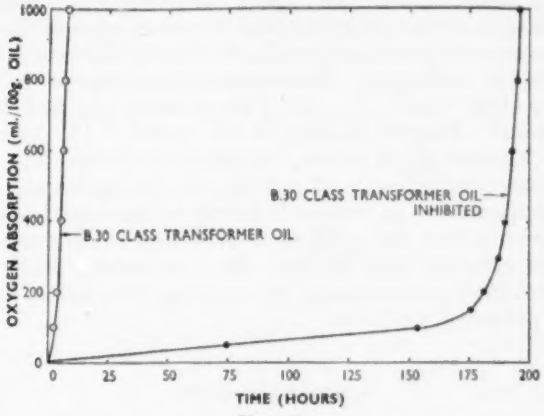

FIG. 8.

OXIDATION RATES OF B.30 CLASS TRANSFORMER OILS WITH AND WITHOUT INHIBITOR.

transformer oil, obtained using the automatic recording equipment of the rather slower laboratory evaluation procedure (Fig. 2). In all the laboratory investigations mentioned, the oils were oxidized to a fixed degree corresponding to the absorption of 1000 ml oxygen per 100 g oil, irrespective of oil type or the reaction time required to achieve this. Oils of varying origins and refinement naturally give rise to different relative amounts of sludge and acidity during the course of these reactions, but the extent of deterioration is comparable to that occurring under service conditions: developed acidities are of the order of 2 to 4 mg potassium hydroxide per g oil, and sludges in the regions of 0·1 to 1 per cent by weight are found. Tests carried out on various oils in the 1-kVA transformers during the course of twelve months resulted in one oil attaining an acidity of 0·85 mg KOH/g, although in this case it seems fairly certain, from the properties of successive samples of this oil taken during the course of the test, that part of this acidity was due to solution of varnish constituents into the oil, and not to oil oxidation. That some acidity is developed as a result of oxidation is shown by two features: (1) an inhibited oil, in an identical transformer, under exactly similar conditions, during the same period, had a neutral-

ization value of 0·2 mg KOH/g, approximately one-quarter of that of the uninhibited oil, this being a measure of the acidity to be ascribed to varnish constituents; (2) Samples of the two oils, inhibited and unihibited, from the 1-kVA transformers were subjected to laboratory oxidations, using the more rapid oxygen absorption procedure. The inhibited oil still retained over 90 per cent of its original stability, based on induction-period measurements. It had an estimated remaining service life approximately nine times greater than the same oil without inhibitor, which, under the same test conditions, was found to have suffered a decrease in stability as measured by the time required to absorb 1000 ml oxygen/100 g oil.

A unique advantage of the graded series of accelerations is thus apparent, for it is possible to obtain valuable information concerning the onset and course of the oxidation reactions in one of the slower field or service tests by subjecting samples of the oils from these to one or other of the more rapid laboratory evaluation procedures, without seriously disturbing the reaction equilibrium in the slower test. An assessment can therefore be made of the concentration of useful inhibitor, and of the probable length of the remaining induction period. This information is not provided by the existing test procedures. Caution is, of course, necessary in interpreting the results, especially where the influence of transformer constructional materials is likely to be important. At present it is only by the use of such a series of graded procedures that the value of an inhibited transformer oil may be demonstrated reliably, and without the uncertainty which the more orthodox acceleration procedures involve, owing to the lack of incorporation of all the " operational variables."

Acknowledgment

The authors are indebted to " Shell " Refining and Marketing Co. Ltd. for permission to publish this paper.

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THE CRUDE OIL OF SUDR, EGYPT

By Ibrahim Youssef* (Member)

Ras Sudr lies on the eastern shore of the Gulf of Suez, approximately 55 kilometres south of Suez, the producing wells, being about four kilometres from the coast.

Geological investigations were carried out as early as 1937 and indicated the possibility of a commercial accumulation of petroleum. Later geophysical surveys confirmed the geological results, and the first well was commenced in February 1946. Oil was found at approximately 2700 feet.

Geological Structure

Structurally the Sudr field is an uplifted block in which the oil is trapped by the sealing action of a big fault on the east side of the field.

The oil accumulation occurs in the neighbourhood of the Miocene/Eocene unconformity at a depth of 2700 feet. The overlying formations are almost entirely of Miocene age, and consist of gypsum and gravels at the surface, followed in depth by shales and anhydrite, then marls and shales.

The actual producing horizon consists of two zones: first, the basal Miocene sandstone, and secondly, the cavernous Eocene limestone, which lies unconformably below.

The deeper formations are Lower Eocene limestone and calcareous beds followed by the Nubian formation. No commercial oil has been found yet in these deeper formations in Sudr.

Production

So far nineteen wells have been completed, eleven of which are producing at rates varying from 250 to 5000 barrels per day. All except one well are producing by natural flow.

The accurate limits of the field are not yet known, and considerably more drilling will have to be done before the available reserves can be calculated.

As produced the oil is almost completely gas- and water-free and is despatched to the refinery at Suez without any treatment.

Nature and Quality of Sudr Crude

Sudr crude is a dark viscous oil, having the following characteristics:

Sp. gr. at 60°/60° F	0·918
A.P.I. gravity at 60°/60° F	22·64
Water, % wt	0·05
Salt, % wt	0·006

* Government Petroleum Refinery, Suez.

Sulphur, % wt	1·934
Ash, % wt	0·008
Carbon residue, % wt	9·703
Asphaltenes, % wt	8·200
Paraffin wax, % wt	4·910
Melting point of wax, ° C	51·5
Acidity, mg KOH/g	Nil
Pour point, ° F	30
Viscosity Red. I at 100° F, sec	283

A.S.T.M. Distillation :

I.B.P., ° C	78
Percentage volatile to 100° C	1·5
,, ,, 125° C	3·5
,, ,, 150° C	7·0
,, ,, 175° C	10·5
,, ,, 200° C	14·0
,, ,, 225° C	18·0
,, ,, 250° C	21·5
,, ,, 275° C	26·0
,, ,, 300° C	32·0

10% volatile to 178° C
20% ,, 244° C
30% ,, 295° C

A comparison of Sudr crude oil with other Egyptian and some Middle East crudes is given in Table I and Fig. 1.

TABLE I

Nature of crude oil :	Egyptian crude oils.						Middle East crude oils.			
	Sudr.	Asl.	Feran.	Gharib.	Hurghada.	Abu Durba.	Bahrien.	Saudi Arabia.	Iran.	Iraq.
Analysis :										
Sp. gr. at 15°/4° C	0·918	0·920	9·912	0·900	0·909	0·974	0·865	0·843	0·837	0·845
Water content, % wt	Trace	0·1	1·6	0·3	0·5	0·6	0·15	Trace	Trace	Nil
Salt content, % wt	0·006	0·003	0·02	0·028	0·032	0·047	0·0022	0·002	Trace	—
Sulphur content, % wt	2·00	2·1	2·04	2·7	2·4	1·98	2·00	2·3	1·30	2·0
A.S.T.M. distillation (100 ml) :										
I.B.P., ° C	78	145	65	62	64	178	46	57	57	52
Percentage volatile to:										
75° C	—	—	1·0	1·5	1·0	—	3·0	2·5	4·5	5·0
100° C	1·5	—	4·5	4·0	4·0	—	7·0	8·0	10·0	10·0
124° C	4·0	—	8·0	8·0	8·5	—	11·5	13·0	17·0	16·5
150° C	7·5	0·5	10·5	13·0	14·0	—	17·0	19·0	24·0	22·0
175° C	11·5	2·5	14·0	16·5	19·0	—	22·0	23·5	29·0	28·0
200° C	14·5	5·5	17·0	20·5	23·0	3·5	26·0	30·0	35·0	34·5
225° C	18·5	10·0	20·5	25·0	28·0	7·5	30·0	35·0	40·0	39·5
250° C	22·0	14·0	24·5	28·5	32·0	11·5	35·0	40·5	45·0	44·5
275° C	26·0	19·0	29·0	32·0	36·5	16·0	40·5	46·0	51·0	49·5
300° C	32·0	24·5	35·0	38·0	40·0	20·0	46·5	54·0	57·0	56·0

LABORATORY BATCH-STILL DISTILLATION

A sample of Sudr crude oil was distilled in conformity with I.P. method C.P. 3a. up to a still temperature of 250° C, atmospheric pressure and superheated steam were employed and twelve fractions were collected, analyses of which are given in Table II.

The residue from the atmospheric distillation was then distilled under a pressure of 4 mm Hg and four fractions collected. These fractions were

heavy gas oil, and light, medium, and heavy wax distillates. Analyses of the wax distillates are given in Table III.

The distillates from both distillations were then bulked in accordance with normal yield of marketable products as shown in Table IV.

Analyses of these bulked distillates and of the bitumen obtained from vacuum distillation are given in Tables III and IV.

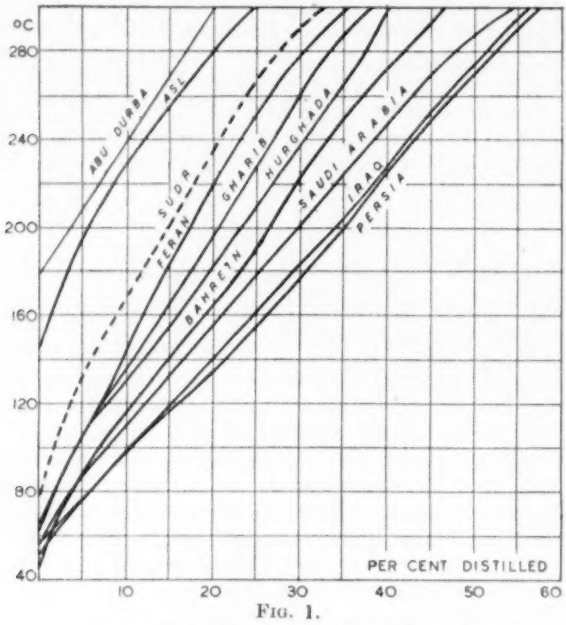

FIG. 1.

A.S.T.M. DISTILLATION CURVES OF SUDR, EGYPTIAN, AND MIDDLE EAST CRUDES.

DISCUSSION OF RESULTS.

Sudr crude is a heavy oil of 0·918 specific gravity (22·54° A.P.I.) at 60°/60° F and a pour point of 30° F. At present the crude is produced dry without any emulsified water, and hence its salt content is low at about 0·006 per cent by wt. The sulphur content is about 2 per cent by wt, but the crude does not smell of hydrogen sulphide nor give light fractions containing hydrogen sulphide.

It contains practically no dissolved gas, and is also characterized by its low volatility, only 1·5 per cent by volume being evaporated at 100° C, 14·5 per cent at 200° C, and 32 per cent at 300° C.

The paraffin wax content (see Appendix I) of the crude is about 5 per cent by wt, and a good asphaltic bitumen is obtained.

Gasoline.

The yield of gasoline is 6·66 per cent by wt on the crude. This gasoline has an end point of 179° C and an octane number (M.M. clear) of 44·7. It

TABLE II

Laboratory Batch-still Atmospheric Distillation Fraction-yields, and their Analyses

Fraction number :	1.	2.	3.	4.	5.	6.
Fraction :						
Vapour temperature, ° C	Up to 50	50–75	75–100	100–125	125–150	150–175
Percentage wt on dry crude	0·20	0·81	1·11	1·99	2·45	2·80
Total distillates, % wt on dry crude	0·20	1·01	2·12	4·11	6·56	9·36
Sp. gr. at 15°/4° C	0·6610	0·6800	0·7085	0·7222	0·7661	0·7700
Colour, Lovibond	W.W.	W.W.	W.W.	W.W.	W.W.	1·25
Flash point, Abel-Pensky, ° F	—	—	—	—	65	78
Total sulphur, % wt	0·046	0·017	0·010	0·012	0·028	0·031
Mercaptan sulphur, % wt	Nil	Nil	0·002	0·003	Nil	Nil
Aromatics, % wt	0·62	0·74	1·00	0·84	2·80	6·34
Aniline point, ° F	147	147	144	149	149	147
Diesel index	—	—	—	96·1	83·0	76·8
Vapour pressure (Reid) at 100° F, lb	6·5	4·7	3·1	1·8	—	—
Octane number, motor method, clear	58	53·2	50·0	48·2	35·8	23·0
Octane number, motor method + 2 ml T.E.L/I.G.	72·5	69·8	68·4	67·0	56·0	44·6
Smoke point, mm	—	—	—	—	46	41
Burning test char, mg/litre	—	—	—	—	8	9
A.S.T.M. distillation :						
I.B.P., ° C	49·0	52	73·0	98·0	127·0	149·0
10%	50·0	55·0	78·5	103·0	135·0	156·0
20%	51·5	56·5	82·0	106·0	137·0	158·0
30%	53·0	58·0	84·0	107·0	139·0	160·0
40%	54·5	60·0	85·0	108·0	140·5	162·0
50%	56·0	63·0	86·0	109·0	142·0	163·5
60%	57·0	66·0	88·0	112·0	144·0	165·0
70%	58·5	68·0	90·0	115·0	146·0	167·0
80%	60·0	74·0	95·0	123·0	151·0	170·0
90%	65·0	82·0	104·0	130·0	160·0	179·0
F.B.P., ° C	74·0	90·0	115·0	141·5	176·0	196·0
Residue, %	1	1	1	1	1	1
Loss, %	1	1	1	1	1	1
Average molar boiling point, ° R	592·8	605·4	646·8	690	747·6	786·3
Characterization factor " K "	12·67	12·44	12·21	12·24	11·85	11·99

Fraction number :	7.	8.	9.	10.	11.	12.
Fraction :						
Vapour temperature, ° C	175–200	200–225	225–250	250–275	275–295	295–310
Percentage wt on dry crude	2·85	3·00	3·70	2·55	3·10	3·74
Total distillates, % wt on dry crude	12·21	15·21	18·91	21·46	24·56	28·30
Sp. gr. at 15°/4° C	0·7865	0·8031	0·8140	0·8310	0·8407	0·8530
Colour : Lovibond	1·75	2·0	2·5	2·75	Over 4	—
Union	—	—	—	—	1½ minus	2 minus
Flash point, P.M., ° F	98	126	132	14	155	172
Total sulphur % wt	0·087	0·136	0·450	0·672	0·720	0·963
Mercaptan sulphur, % wt	Nil	Nil	Nil	Nil	Nil	Nil
Aromatics, % wt	9·5	12·5	20·3	31·4	31·6	34·0
Aniline point, ° F	148	154	154	154	156	159
Diesel index	71·8	69·9	65·2	59·7	57·6	54·7
Pour point, ° F	—	—	—	below −10	0	20
Smoke point, mm	34	32	29	23	21	20
Burning test char, mg/litre	13	14	17	39	45	185
Octane number, motor method, clear	18·3	10	8·7	—	—	—
Octane number, motor method + 2 ml T.E.L/I.G.	36·5	29·2	28·8	—	—	—
Refractive index at 40° C	1·4280	1·4362	1·4420	1·4537	1·4591	1·4660
Kinematic viscosity cs at 20° C	1·53	2·10	2·67	3·63	4·47	6·80
A.S.T.M. distillation :						
I.B.P., ° C	173·5	199·0	221·0	247·0	273·0	294·0
10%	182·5	207·0	226·5	249·0	275·0	300·0
20%	185·0	209·0	227·0	250·5	276·0	301·0
30%	187·0	210·5	229·0	252·0	278·0	302·0
40%	188·5	212·0	231·0	254·0	279·0	303·5
50%	190·0	213·5	233·0	256·0	280·0	305·0
60%	191·5	214·5	235·0	258·0	282·0	306·5
70%	193·0	216·0	237·0	260·0	284·0	308·0
80%	195·0	218·0	240·0	263·0	288·0	312·0
90%	201·0	225·0	247·0	270·0	295·0	320·0
F.B.P., ° C	219	235	261	281	306	329
Residue, %	1	1	1	1	1	1
Loss, %	1	1	1	1	1	1
Average molar boiling point, ° R	834	876·3	911·4	952·8	996	1041
Characterization factor " K "	11·97	11·96	11·91	11·84	11·87	11·90

TABLE III

Analyses of Bulked Products from Batch-still Atmospheric and Vacuum Distillations

Products.	Gasoline.	Kerosine.	Gas oil.	Light wax dist.	Medium wax dist.	Heavy wax dist.
Sp. gr. at 15°/4° C	0·723	0·803	0·856	0·900	0·921	0·933
Colour : Lovibond	0·5	2·5	—	—	—	—
Union	—	—	2	2·5	4	Darker than 8
Flash point, ° F	—	126	182	296	345	397
Pour point, ° F	—	—	22	78	110	130
Aniline point, ° F	—	153	163	170	180	188
Smoke point, mm	—	29	—	—	—	—
Total sulphur, % wt	0·034	0·248	1·08	1·580	1·730	1·842
Mercaptan sulphur, % wt	0·003	—	—	—	—	—
Aromatics, % wt	0·23	9·8	21·7	—	—	—
Conradson carbon, % wt	—	—	0·010	0·073	0·085	0·097
Asphaltene, % wt	—	—	0·006	0·01	0·013	0·022
Wax, % wt	—	—	—	14·50	29·33	34·86
M.p. of wax, ° C	—	—	—	50·7	52·0	55·88
Diesel index	—	68·4	55·94	43·7	39·8	37·9
Refractive index at 40° C	—	—	1·4700	1·5000	1·5061	1·6533
Viscosity kinematic, cs, at :						
70° F	—	—	—	—	—	—
100° F	—	—	—	19·5	—	—
140° F	—	—	—	9·6	28·8	—
210° F	—	—	—	4·0	9·5	14·2
Viscosity : Red. I. at 100° F, sec	—	—	35	128	—	—
Octane number, M.M.	44·7	—	—	—	—	—
Vapour pressure (Reid) at 100° F, lb	3·2	—	—	—	—	—
Char, mg/litre	—	25	—	—	—	—
A.S.T.M. distillation :						
I.B.P., ° C	59	167	261	—	—	—
10%	82	184	270	—	—	—
20%	97	192	274	—	—	—
30%	108	200	278	—	—	—
40%	115	206	282	—	—	—
50%	123	212	286	—	—	—
60%	131	218	290	—	—	—
70%	140	228	296	—	—	—
80%	149	239	313	—	—	—
90%	159	256	326	—	—	—
F.B.P., ° C	179	283	367	—	—	—
Residue, %	1	1	1	—	—	—
Loss, %	1	1	1	—	—	—

TABLE IV

Products from Laboratory Distillation of Sudr Crude Oil

Product.	Composition.	Percentage yield.
Gasoline	Fractions Nos. 1 to 5 and part of No. 6 to vapour temp of 160° C	6·66
Kerosine	Remainder of Fraction No. 6 and Fractions Nos. 7 to 10	14·30
Gas oil	Fractions Nos. 11 and 12 and heavy gas oil fraction (to 200° C) from vacuum distillation.	15·20
Light wax distillate	Vacuum distillate 200–230° C	6·58
Medium wax distillate	Vacuum distillate 230–260° C	6·15
Heavy wax distillate	Vacuum distillate 260–305° C	14·59
Bitumen 5/10	Vacuum distillate above 305° C	35·75
	Distillation loss	0·27
		100·00

TABLE V

Analysis of Bitumen from Laboratory Batch-still Vacuum Distillation, 4 mm Hg

Sp. gr. at 25°/25° C	1·0381
Penetration at 25° C	7
Ductility at 25° C, cm	17
M. p. (R and B), ° C	66
Ash, % wt	0·274
Sulphur, % wt	3·493
Asphaltene, % wt	23·160
Wax, % wt	3·150
Solubility in CCl_4, wt	99·750
,, CS_2, wt	99·800
Saponification value, mg KOH/g	8·00
After 5 hr heating at 163° C:	
Loss in weight, % wt	0·015
Penetration at 25° C	6
Ductility, at 25° C, cm	12
M.p. (R and B), ° C	68·5
Drop in penetration after heating, %	14·28

is free of hydrogen sulphide, but contains 0·003 per cent of mercaptans. When treated with 20 per cent caustic soda, the mercaptans were reduced to 0·001 per cent, but the octane number was only increased to 45. The lead response of the gasoline is shown in Fig. 2.

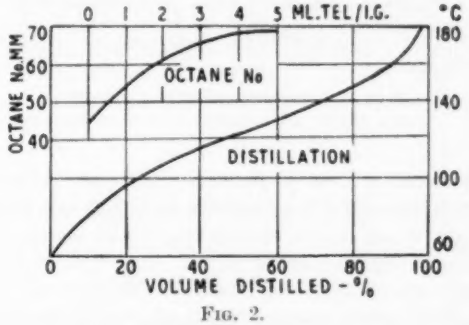

FIG. 2.

SUDR STRAIGHT-RUN GASOLINE.

The low aromatic content—about 0·2 per cent—also affects the octane number. The vapour presssure (3·2 lb) is very low and would permit the addition of butane to raise it to about 8 lb to give a gasoline having an octane number of 56·4 M.M. clear.

Gasoline from Sudr crude is of poor volatility, with 22·5 per cent evaporated at 100° C, and 70 per cent at 140° C.

Kerosine

Kerosine is obtained in a yield of 14·8 per cent. Its boiling range is 167° to 282° C, with a volatility of 30 per cent to 200° C. The effect of treatment on colour, smoke point, and sulphur content is shown in Fig. 3. The kerosine contains nitrogen bases which although not detectable by odour give a copious precipitate in the silicotungstic acid test.

The low octane number of 17·3 renders the kerosine unsuitable as a tractor fuel.

Gas Oil

The yield of gas oil is 15·2 per cent, and it has a boiling range of 261° to 367° C and a volatility of 73·5 per cent at 300° C. Other properties are good, and this product would make a suitable fuel for high-speed diesel engines.

Wax Distillates

The three wax distillates were obtained as bright stocks without any decomposition. Their colour is good, varying from blue and bluish-green fluorescence for the lighter fractions to green bloom for the heavy distillate.

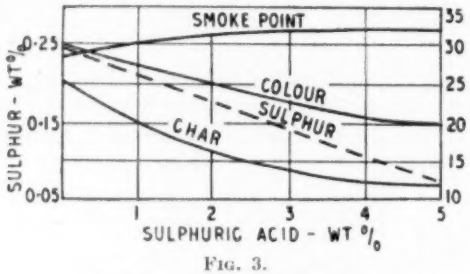

Fig. 3.

ACID TREATMENT OF SUDR KEROSINE.

Bitumen

The yield of bitumen is from 35 per cent (5/10 pen) to 50 per cent (80/100 pen). It has been used for road purposes in Egypt and found satisfactory.

Large-scale Treatment

When processed in a conventional atmospheric distillation unit to give a residual fuel oil of 1500 sec Redwood I at 100° F, the following yields were obtained :—

	Per cent by wt.
Gasoline	7
Kerosine	8
Fuel oil	85

This would not be economical. In order to obtain all the kerosine and most of the gas oil, as well as producing a fuel oil of 1500 see viscosity, other treatment must be considered. The flow diagram in Fig. 4 is suggested.

Crude Section

This is a conventional atmospheric distillation unit, from which light gasoline is obtained as an overhead. After condensation, this gasoline is soda treated and passed to storage.

Naphtha, kerosine, and gas oil are taken off as side streams, then steam stripped and taken through heat exchangers to storage.

Yields from this section would be approximately :—

	Per cent.
Gasoline	6·5
Kerosine	14·5
Gas oil	9·0
Residual fuel	70·0

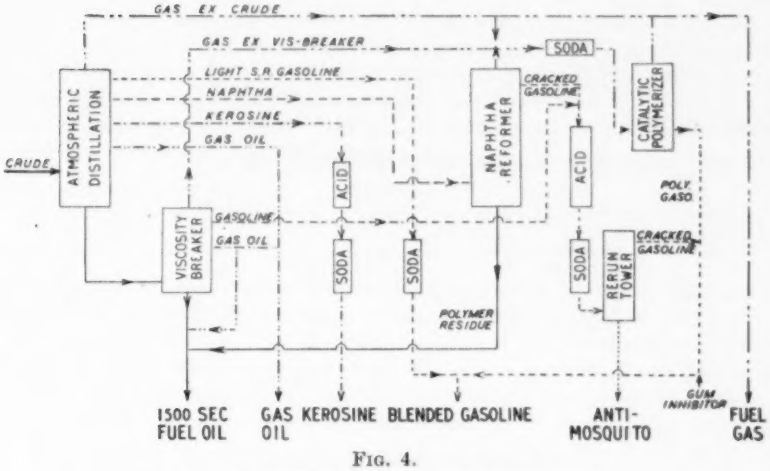

FIG. 4.

PROPOSED REFINING SCHEME FOR SUDR CRUDE.

Vis-breaking Section

Feed to this section is the residual fuel from the crude tower. After preheating, the feed enters the fractionator, where the lower-boiling range materials are flashed and pass upwards through the fractionator, while the unflashed oil is discharged as finished fuel of 1500 sec viscosity.

Vapours leaving the top of the tower are condensed and stabilized, the gasoline being acid treated and taken to storage, while the uncondensed gases are passed to the fuel-gas system.

Yields from this section are :—

	Per cent.
Gasoline	3·0
Fuel oil	93·0
Gas and loss	4·0

Naphtha Reforming

Naphtha from the crude section is charged to the reformer, from which gas and reformed gasoline are taken as overheads and fuel oil from the bottom of the tower is flashed in the vis-breaker fractionator and removed as finished fuel oil.

The reformed gasoline flows to a debutanizer, then to the treating system and to storage. Uncondensed gas enters the fuel-gas system.

Catalytic Polymerization

The debutanizer overhead, consisting of butanes and lighter, are partially condensed and the condensed portion pumped to the catalytic polymerization reactors, where the propylenes and butylenes are polymerized. The effluent goes to the depropanizer, the bottoms from which, after cooling, are blended with previously obtained gasolines to give a blend of 75 octane number M.M. clear. The overhead joins the fuel-gas system.

Yields from the naphtha-reforming and catalytic polymerization sections are :—

	Per cent.
Gasoline	70
Polymer	8
Gas and loss	22

Overall Yields

Overall yields from this scheme of processing will be :—

	Per cent by wt.
Gasoline	6·5
Kerosine	14·5
Gas oil	9·0
Fuel oil	65·5
Gas and loss	4·5

APPENDIX

Determination of Wax Content

1. For dark petroleum products such as crude oil, fuel oil, and bitumen.

For the removal of volatile fractions 100 g of the sample is distilled to a liquid temperature of 340° C, and for the wax distillate 40 g of the residue is distilled until the residue is completely converted to coke.

2 to 3 g of the wax distillate is distilled in a mixture comprising equal parts of ether and absolute alcohol and the mixture cooled to −20° C. The cold solution is filtered and the separated wax washed with cold (−20° C) ether alcohol solution until the filtrate is colourless. The wax in the filter is diluted in hot 60° to 80° C petroleum ether, whereby asphaltic impurities are left on the filter. The petroleum ether is then evaporated from the wax, which is finally dried in an oven at 105° to 110° C until constant weight is obtained.

The wax can be further purified by re-crystallization from acetone.

EVALUATION OF CRUDE OIL

By the Evaluation Panel of I.P. Standardization Sub-committee No. 2—Crude Oil

Early in 1948 the attention of Sub-committee No. 2 of the Standardization Committee was directed towards the possibility of evolving a standard method for the evaluation of crude oil. It was soon realised, however, that owing to the diverse characteristics of crude oils and to the fact that many oil companies had evolved their own methods of crude oil evaluation, it was impracticable to specify a rigid procedure to be followed in all cases. In order to pursue the matter further an Evaluation Panel of the Sub-committee consisting of the following :—

L. C. Strang (*Chairman*)	Anglo-Iranian Oil Co. Ltd.
D. H. Japes (*Deputy Chairman*)	"Shell" Refining and Marketing Co. Ltd.
A. Crossfield	"Shell" Refining and Marketing Co. Ltd.
H. Jagger	Anglo-American Oil Co. Ltd.

was formed with the object of considering methods for the evaluation of crudes, and to formulate a scheme or recommended procedure for this.

The Panel decided that in the first instance it was desirable to publish a paper indicating the principles involved, suitable types of equipment to be used, precautions to be taken, etc. It is emphasized that this account is not intended to give a comprehensive survey of methods of crude oil distillation, but the features dealt with are those which it is felt might be of value to persons interested in this type of crude oil analysis. While it is possible by simple methods such as I.P. 24 to detect major differences between crude oils, experience has shown that such methods of analysis are totally inadequate for complete crude oil evaluation. The principles outlined in this paper enable an evaluation to be made from which the yields and qualities of potential products may be derived.

Comments and criticisms are invited, and suggestions as to aspects of the subject which might be modified or dealt with more fully will be particularly welcome. Such comments should be sent to the Technical Secretary of the Institute of Petroleum for consideration by the Sub-committee and Panel concerned.

Introduction

While most of the major oil companies have evolved their own methods of laboratory crude oil evaluations, only very limited data are available in the literature.[1] Owing to the diverse characteristics of crude oils it is considered impracticable to specify a rigid procedure to be followed in all cases, and it is the intention in this paper to set out rather the principles involved in the laboratory evaluation of a crude oil, thereby obtaining data which will enable a refiner to assess the yields and properties of the straight-run products derived from it. It is not always necessary or indeed possible to complete all the operations described below; only such parts of the evaluation that are immediately required by the refiner would, in many cases, be carried out.

Principle

The crude oil is distilled to obtain the boiling-point curve and provide a number of relatively narrow-boiling distillate fractions which may be analysed separately and/or back blended into the desirable boiling-range refinery products for further examination. Owing to the diverse forms of laboratory or pilot-plant distillation equipment in common use, it is considered undesirable to specify any one apparatus but to give a broad outline of the main principles involved, and to list the factors necessary and precautions to be taken to get accurate and reproducible results. Four distinct types of distillation equipment are necessary to assess the following parts of the crude oil :—

(*a*) light hydrocarbons ;
(*b*) light and middle distillates and residual fuels ;
(*c*) heavy distillates and lubricants ;
(*d*) bitumens.

In general items (*a*) and (*b*) will furnish data of value for the operation of refinery gas fractionators and crude distillation units, and are much the more important sections of the evaluation. Items (*c*) and (*d*) concern the operation of the vacuum towers of the refinery crude oil units.

It must be emphasized that good reproducibility of results is required from the laboratory equipment and operating conditions specified in this paper, and that the fractionation efficiency is, in general, better than that obtained in refinery crude oil distillation equipment. Due allowance must be made for this in comparing laboratory and refinery products.

Sampling

Reference should be made to the methods for sampling petroleum and petroleum products (I.P. 51). Crude oil may best be sampled from a pipeline, but in many cases, such as an advance sample of a new type of crude, the sample may well arrive in a barrel or similar type of container. It should be realized that, unless the crude has been stabilized to be substantially propane free, some loss of light ends is likely to have occurred, and hence the determination of the light hydrocarbons content is of doubtful value. To a lesser extent this may also be true for propane-free crude oils. The barrel should be rolled and the crude tested for deposition of waxy settlings (sludge) by scraping the bottom with a rod before withdrawing a sample. If any settlings are detected, the barrel should be warmed and further rolled until the contents have become homogenized.

Evaluation of Crude Oil

(*a*) *Light Hydrocarbons*

Apparatus.—A low-temperature fractional-distillation apparatus, as commonly used for the analysis of hydrocarbon gases, is used in conjunction with a simple still.[2] This latter consists of a half- or one-litre round-bottomed flask with side arm. The flask is attached to a column, about 1

inch diameter and 8 inches high, packed with caustic soda pellets for removal of water vapour and acidic gases. The top of this column is closed by a thermometer pocket, and a side arm attached to the low-temperature fractional-distillation apparatus.

Procedure.—The whole apparatus is evacuated and the crude oil charge drawn into the flask. The oil is then heated and the distillate condensed in the distilling bulb of the low-temperature distillation apparatus. If butanes and light hydrocarbon contents only are required, the primary distillation of the crude oil should be continued to a column-top temperature of *ca* 135° F, but if pentanes content is also required it should be continued up to *ca* 215° F. The analysis of the condensate in the bulb is then carried out in the usual manner and the results computed to the original charge of crude oil.

(*b*) *Light and Middle Distillates and Residual Fuels*

This is the most important section of the assessment of a crude oil, and in many cases would be the only part carried out.

Apparatus.—The type of apparatus used must be capable of producing a true boiling-point curve in which the reproducibility in distillate yield at any given cut point shall not show a variation greater than 1 per cent. The recovery should be not less than 99·5 per cent. The apparatus must be suitable for producing distillates at a cut point equivalent to not less than 700° F at atmospheric pressure.

The following are essential features of the fractionating equipment :—

Fractionation efficiency. Not less than 14 theoretical plates at atmospheric pressure.
Reflux ratio. Not less than 5 : 1.
Charge/hold up ratio. Not less than 20 : 1.
Column to be capable of operation under vacuum.
Column to be electrically lagged.
Refrigerated coolant to be available for condensers and receivers during the early stages of the distillation.

The size of the equipment to be used is a matter of convenience. The essential features of two suitable types are described below, but the use of other types of apparatus and column packing are permissible provided that the conditions given above are fulfilled.

One-gallon Glass Still. This must be regarded as the largest size that can be erected in glassware, *i.e.*, the still consists of a round-bottomed 5-litre flask. If more convenient a 3-litre flask may be used, but this is the minimum size recommended to use in conjunction with the column described. With most crudes the 5-litre still will provide fractions large enough for all the essential analytical tests with the exception of octane numbers of gasolines, for which purpose it would be necessary to carry out further distillations. The apparatus should be constructed from heat-resistant glass, using standard cone and socket joints and a suitable lubricant resistant to the high temperatures encountered and the solvent action of the oil.

The still consists of a 5-litre round-bottom flask fitted with a standard

socket (B.34 is a convenient size). Incorporated in the flask is a thermocouple pocket which extends to nearly the bottom of the flask and is used in measuring the still temperature. The still rests in a heater-box containing two separate heating elements; a flat 750-watt heater on the floor and a 500-watt mat heater around the inside wall, which is made of asbestos board and glass wool to reduce heat losses. These heaters are separately controlled by variable transformers, rheostats, or suitable "on–off" controllers. Commercial heaters and mantles may be obtained suitable for any standard size flask. The box may conveniently be supported on a tripod whose height can be adjusted evenly by means of a sprocket and chain drive. Alternatively, the still may be gas-heated, in which case the upper portion of the flask should be lagged. From the fire hazard, gas heating is less desirable, but in any case the tripod carrying the heater should stand in a tray large enough to hold the whole oil charge in the event of a flask breakage.

A reflux meter, consisting of an internal vapour upriser protected from the down-coming liquid reflux by a small umbrella, is placed between the still and column. The boil-up rate is measured intermittently by placing a steel ball in a ground valve seat by means of a magnet and timing the collection of a volume of liquid in the calibrated portion of the reflux receiver. After some experience the reflux meter can be omitted, controlling the boil-up rate by the heat input to the still.

The column consists of a single length of glass tubing about 36 mm internal diameter and 2 mm wall thickness with a socket (B.45) at the top and a cone (B.34) at the base. The overall length should be about 4 feet 6 inches, of which about 4 feet are packed. The packing consists of tinned brass or preferably stainless-steel boot eyelets, the characteristics of which are given below :—

Outside diameter (mean)	0·457 cm
Inside diameter (mean)	0·414 cm
Length	0·368 cm
Rim diameter	0·660 cm
Thickness (mean)	0·036 cm
Weight (average)	0·10 g.
Total surface area	1·4965 sq. cm.
Volume (by displacement)	0·011 cu. cm.
Number per litre	8750
Free space, cu. ft/cu. ft. of packing	0·904
Surface area, sq. ft/ cu. ft. of packing	395

The column is lagged with two 2-feet pipe sections of rigid glass wool which contain internally wound heating elements connected in parallel, controlled by variable transformers or rheostats and capable of producing a maximum operating temperature well above 580° F. Thermocouples are also placed in the lagging and beside the column wall so that the temperature gradient across the lagging can be eliminated by use of the lagging heater elements.

The column head carries a total condenser, which returns the reflux to the column; a thermometer pocket and a connexion to the product receiver via which the product is withdrawn at the desired rate from the reflux stream through an offtake tap. That part of the column head in which the overhead thermometer is located is insulated, preferably with a silvered vacuum jacket, to minimize radiation of heat from the thermometer bulb

which could cause false thermometer readings. The thermometer is located in a thin-walled pocket; such an arrangement permits changing of thermometers without interrupting the distillation. Appropriate corrections for exposed stem should be made. Alternatively, a thermocouple may be used. Normally the overhead condenser is cooled with water, but provision must also be made for cooling to temperatures as low as −10° F in the initial stages of the distillation, with methanol externally cooled by solid carbon dioxide or a separate refrigeration unit. Under these conditions, butane may be refluxed at the top of the column and a good separation between butanes and pentanes obtained.

The distillate receiver is divided into two parts so that the previous fraction may be removed without varying the column-head pressure and so interrupting the distillation. Both these receivers are enclosed in an outer jacket. During the initial stages of the distillation refrigerated coolant is circulated through this jacket to prevent loss. Through the greater part of the distillation, condenser water is used in this jacket, but during the final stages it is necessary to circulate hot water to keep the high-boiling waxy constituents in the fluid state.

Provided care has been taken in building the unit to minimize leaks, this distillation set may be operated at column-head pressures down to 2 mm Hg using a single rotary type vacuum pump. For steady operation it is advisable to have a capacity vessel attached to the pump and a control system connecting the pump reservoir to another capacity vessel maintained at the required constant pressure by a manostat, relay and electrically operated control valve, and a series of manometers to measure the pressure at the column head, the distillate receiver, the pump reservoir, and of the atmosphere. For many crude oils it may not be necessary to operate at column-head pressures lower than 10 mm Hg, and such a pressure may be maintained by a hand-controlled air leak.

It is advantageous that as many as possible of the controls, indicators, and safety devices should be located on a central control panel, the actual form of which is a matter of individual choice.

The column as described above has a flooding boil-up rate of 7000 ml/hr when operated at atmospheric pressure. A convenient operating boil-up rate for atmospheric pressure is 4500 ml/hr. Reduction of the working pressure reduces this value, and at 10 mm pressure operation the boil-up rate is 1000 ml/hr. At atmospheric pressure this column is equivalent to fourteen theoretical plates when testing a mixture of benzene–ethylene dichloride at a boil-up rate of 6000 ml/hr.

Five-gallon Metal Still. A description follows of a metal distillation unit suitable for taking a still charge of 5 gallons. It may be considered more desirable to increase this size to 20 or even 50 gallons still capacity, in which case the fractionating-column diameter and subsidiary equipment should be increased in size to avoid excessive distillation time.

In principle, this type of distillation equipment is the same as the 1-gallon glass type, the chief differences being as follows: The still should be of stainless-steel construction and be fitted with a valve inlet for charging, deep thermocouple for temperature recording, a vacuum/pressure gauge for direct reading of still pressure, and the column attachment. The component parts should be fitted together with flanged joints in place of the cone-and-

socket glass type. The still may be electrically or gas heated. A suitable fractionating tower would be 7 feet high by 2 inches internal diameter, packed with glass tubing 7 mm dia by 7 mm length, or ¼-inch Lessing rings. The column should be heated with three to six strip heaters connected in parallel and controlled by rheostats or variable transformers. The boil-up rate may conveniently be measured by the pressure drop between the still and the column top, this having been previously calibrated by other means such as heat balance over the condenser or heat input to the still. With a unit of this size it is desirable to pass the distillate product through a cooler before entering the receiver. The distillate receivers should, as before, be jacketed and cooled in the early stages of the distillation.

With these larger units it is more difficult to maintain a low pressure than with the 1-gallon all-glass unit previously described. There is no difficulty, however, in operating at column-head pressures down to 10 mm Hg, which with most crudes will allow a corrected column-head temperature of 700° F to be reached. In order to continue this distillation beyond 700° F in the same still (see under Section (*d*) a side arm attached to the base of the column may be incorporated in the design. Condensing and receiving equipment are attached to this side arm, and the distillation may be continued via the side arm instead of up the column.

If, as described under procedure, it is desirable to prepare a gasoline retaining the butane present in the crude oil, it is preferable to have a separate stabilizer to receive this cut. Removal of propane can then proceed while subsequent gasolines are being distilled. A suitable stabilizer for use with the 5-gallon metal still consists of a cylindrical receiver of 4-inch internal diameter stainless-steel tubing 24 inches high. This should be enclosed in an open-topped 8-inch diameter jacket to facilitate cooling by solid carbon dioxide and subsequent water heating. The circumferential jacket should also be fitted with an air-line and an electric heater of 1000 watts capacity in series with a variable resistance. The bottom of the stainless-steel vessel has a ½-inch sample drawoff cock, and the outer jacket has a ¼-inch drain cock. Top connexions to the receiver consist of ½-inch stainless-steel connexion from the still condenser, a ball float or other level indicating device, and a 1-inch vapour-exit line 15 to 20 inches long leading up to a 2-inch stainless-steel column 3 ft long fitted with stainless-steel discs and doughnuts. This packing should comprise 14 discs 1¼ inch diameter and 14 doughnuts ¾ inch I.D.—1⅞ inch O.D., equally spaced by three rods of ⅛ inch stainless steel, but other suitable packing may be used. The lower end of the 1-inch vapour exit carries a 4-mesh stainless conical screen, while a similar mesh screen situated 5 inches below the top of the 2-inch column carries 3 inches of 1 mm cut-glass tubing. The tower terminates in a ¾-inch outlet which carries a thermocouple and from which the gas outlet is taken. The upper 2 feet 6 inches of the tower is surrounded by an 8-inch diameter jacket with open top and bottom drawoff cock. Open manometers are connected to the receiver inlet and gas-outlet lines.

Procedure. In any laboratory evaluation the yields of product should be measured on a weight basis; the yields by volume may be calculated afterwards from a knowledge of the specific gravities. A weight balance should be carried out, and the unaccounted-for loss should not exceed 0·5 per cent wt. The light condensate in the product receiver may be transferred to a

cooled, evacuated pressure receiver for weighing. Any uncondensed gases should be metered and allowance made.

The specific gravity and water content of the crude oil should be measured just prior to charging the still. In the case of heavy crudes the presence of water may cause difficulty in the early stages of distillation. While this may be overcome by using a smaller charge for any given still, it may be necessary to dehydrate the crude. Suitable procedures may be found in I.P. 24. Refrigerated coolant should be passed through the condenser and heat applied to the still and column. The unit should operate steadily under total reflux before any liquid distillate is withdrawn.

Although the incidence of cracking depends to some extent on the nature of the crude, it is recommended that the temperature of the oil in the still should not be allowed to exceed 600° F. When it becomes necessary to lower the operating pressure, the still must be allowed to cool back before applying vacuum. It is essential that a steady operating pressure be maintained, as fluctuations lead to unsteady operation and flooding of the column.

In evaluating a crude oil, important characteristics are the yield and properties, especially octane number, of the straight-run gasoline. In general, it is the octane number which determines the cut point of the straight-run gasoline which can be incorporated in motor spirit. This may be as low as 200° F or as high as 400° F. In a laboratory evaluation, therefore, it is necessary to establish the yield–end point–octane number relationship of the gasolines. In this connexion, the butane content plays an important part. In most modern refineries it is possible to recover 80 to 90 per cent of the butane in the crude for gasoline production. In the laboratory there are two possible means of approach :—

(i) Reject all the butane by preparing and examining debutanized gasolines, allowing for the effect of added butanes by calculation. With the equipment and procedure recommended above, a fairly good separation between butane and pentane may be obtained by cutting at an overhead temperature of 60° F. At this point the overhead temperature is rising rapidly, being midway between the boiling points of *n*-butane and *iso*pentane.

(ii) Retain all the butane in the gasoline. This may best be attained by passing the gas and gasoline overhead (up to *ca* 200° F cut point) from the main column direct into a stabilizer as previously described. In such a case it is no longer necessary to have refrigerated coolant in the condensers of the main column as total condensation (except for any methane and ethane) will take place in the stabilizer. The primary gasoline cut is received in the stabilizer with the bath round the tower cooled to −55° F with solid carbon dioxide in kerosine or methanol, and the receiver bath chilled with solid carbon dioxide. When the desired cut has been received, stabilization is carried out by blowing off residual carbon dioxide and subsequently filling the jacket with water, which is heated electrically. Heating is controlled to give a vapour temperature such as will not cause flooding but will maintain a 1-inch water differential between receiver and vapour outlet. Stabilization to a vapour temperature of −10° F at a gas rate not

exceeding 0·04 cu. ft/minute will ensure a propane-free product and a butane content in the exit gas of no more than 1 per cent.

If the removal of butane is desired as under (i) above, the stabilization can be continued to give a vapour temperature of 60° F. Alternatively, a desired Reid vapour pressure or volatility can be obtained by partial butane removal at an intermediate temperature.

Having obtained by either of the above means the lightest gasoline required the distillation is continued, taking narrow fractions each amounting to say 3 per cent crude, or alternatively at intervals of *ca* 25° F in the overhead temperature, each fraction being weighed. When the overhead temperature has reached about 180° F, the circulating refrigerant in the condensers should be replaced by water. By the above means the distillation is continued up to a corrected overhead temperature of 700° F if possible, vacuum being applied when necessary in order to keep the still temperature below 600° F. Temperatures at reduced pressure should be converted to corresponding temperatures at 760 mm Hg pressure, using the chart given in "Standard Methods for Testing Petroleum and Its Products."

Operating pressures are dependant to some extent on the height and type of packing in the column, but the following have been found suitable when using either three or two pressures during a distillation :—

	Pressure, mm Hg.	Vapour overhead temperature, ° F *
1	760	up to 350
	100	350–500
	2	500–700
2	760	up to 430
	10	430–700

* Corrected to 760 mm Hg pressure.

The essential conditions that must always be fulfilled are :—

(i) still temperature never above 600° F;

(ii) overhead temperature at reduced pressures never too low for complete condensation at the condenser coolant temperature.

When the distillation has finished, the contents of the still must be allowed to cool down to *ca* 450° F before removal. The hold up in the column should be recovered by refluxing a suitable solvent such as benzene up the column. The solvent should then be removed from the recovered hold up, which should be added to and blended with the residue.

From the true boiling-point curve thus obtained, the yields of any product of given boiling range may be deduced. The narrow-boiling fractions may be analysed separately, or blended in aliquot proportions to form a number of possible refinery products for subsequent analysis. For example, the debutanized or stabilized light gasoline is blended with the succeeding narrow distillates to form say four gasolines covering the end points between 200° F and 400° F. Similarly, refinery products such as

reforming naphthas, white spirits, kerosines, and gas oils may be obtained for examination. In addition, the residue from the distillation should be back blended with the heavy distillates to form a series of residues of various front-end cutting points on crude for analysis.

It is recommended that the blended products be examined by the following tests, which are regarded as the most valuable, but these may be augmented if thought necessary :—

Gasolines	Specific gravity, distillation, sulphur and mercaptan sulphur, octane number, and lead responses.
Reforming naphtha	Specific gravity, distillation, sulphur, octane number.
White spirits and kerosine	Specific gravity, distillation, sulphur and mercaptan sulphur, aromatic content, smoke point.
Gas oils	Specific gravity, distillation, sulphur, aniline point, pour point, and viscosity at 100° F.
Residues	Specific gravity, sulphur, asphaltenes, carbon residue, pour point, viscosities at 140° F and 210° F.

If the gasolines are high in sulphur content, the lead responses are of little value on unrefined materials, as a sulphur-removal refining treatment would probably be applied in the refinery. In such cases it is recommended that the gasolines be treated in the laboratory by the same type of refining treatment, say solutizer or acid and re-running, as used in the refinery, and the lead responses carried out on the refined samples. If a sweetening process only is used, the lead responses will not be appreciably different from those of the unrefined gasolines.

Cleaning of the Still. It has already been pointed out that the hold up in the column should be recovered by refluxing with benzene or other suitable solvent. It is highly desirable to make this clean out with a solvent which is capable of dissolving sulphur and resinous compounds which may be deposited in the still, the tower, and overhead equipment. Some of the solvent should be distilled overhead to clean the overhead equipment. If this method of cleaning is not used the first gasoline cut of the next distillation may pick up sulphur previously deposited in the tower and hence a falsely high result may be obtained.

(c) *Heavy Distillates and Lubricants*

The complete evaluation of a crude oil for lubricating-oil production requires a considerable amount of equipment and effort, and the treatment given below does no more than indicate the possibilities of a crude oil for lubricating-oil production. It does not enable the yields of or solvents requirements for finished lubricants to be deduced. For the examination proposed a suitable starting material is either :—

(i) residue above 700° F;
(ii) long wax distillate produced in association with the shortest bitumen prepared as described later.

Of the two, (i) is rather more suitable than (ii).

One of the above feedstocks should now be distilled into a number of fairly narrow fractions. In order to distil in this boiling range without cracking it is necessary to have a very low pressure in the still, and, to avoid

pressure drop, the fractionating column as used for the lighter distillates must be dispensed with.

The still to be used must, therefore, be of simple construction, the main feature being the ability to maintain a low pressure, preferably as low as 0·05 mm Hg in order to allow the distillation to proceed as far as possible. Experience shows that to attain this low pressure it is necessary to employ a mercury diffusion pump backed by a rotary vacuum pump. Electrical heating is preferable to gas firing to avoid local overheating, and the apparatus must be well lagged. Measuring the overhead temperatures in such a still is not recommended, as these are of no value unless very special precautions are taken to measure the low operating pressures very accurately. A still taking a charge of 1 to 1½ litres is a convenient size, and cutting into 10 per cent distillate fractions would be a suitable procedure.

Alternatively, if the larger metal type of still, previously described, is used for the distillation up to 700° F, a side arm attached to the base of the column may be incorporated into the design. A condenser and receiver are attached to this side arm and the original distillation continued via the side arm instead of up the column. This avoids any handling of the residue, but it will not be possible to operate under nearly so low a pressure as in a small glass still, or to carry the distillation so far into the crude oil.

The chief property which these narrow fractions should be examined for is viscosity, and in this way a plot of viscosity versus mid percentage on crude may be obtained. In this portion of the crude the mid percent distillate–viscosity curve now takes the place in importance of the true boiling-point curve in the lower boiling range. If a waxy crude is being evaluated, it is desirable to carry the evaluation a stage further by dewaxing all or at least some of the fractions to zero pour point. This may conveniently be carried out by simple dewaxing experiments in which the waxy oil is mixed with 10 volumes of methylene chloride or other suitable solvent, cooled to a temperature of −25° F, and filtered, followed by washing the wax cake free of oil with the chilled solvent. The solvent is afterwards removed from the dewaxed oil by distillation aided by a stream of inert gas such as nitrogen. The dewaxed oils should be examined for kinematic viscosities at 100° F and 210° F to enable the viscosity index and the viscosity change on dewaxing to be obtained.

(*d*) *Bitumens*

For refineries interested in bitumen production, the crude oil should be evaluated to determine the yield of bitumen of given penetration, and to examine the bitumens produced in particular for softening point and penetration to determine whether air blowing is necessary to produce specification grades. It is considered to be impracticable, except in the case of heavy asphaltic crudes, to produce bitumen by batch distillation in the laboratory, and it is generally necessary to use a continuous still under vacuum acting on the single-flash principle without fractionation or separate stripping of the residue. This is a modification of that previously described in the literature [3] for continuous distillation of crude oil. Such an apparatus would operate on the residue above 700° F produced as previously described, splitting it into a raw lubricating oil distillate and a bitumen.

The essential features of the apparatus consist of a combined preheater and de-aerator, heater tube, flash chamber, bitumen seal and receiver, and distillate condenser and receiver. The charge is heated by steam or electric heaters, subjected to vacuum in the de-aerator, and then drawn from this vessel by means of a pump to pass through an electrically heated tube. It vaporizes as it passes through the tube, thereby assisting heat transfer and ensuring a low skin temperature, and the mixture of vapour and liquid then enters through a tangential inlet into a flash chamber. The latter is provided with a spiral-shaped groove, round which the mixture of vapour and liquid swirls during which time equilibrium at the pressure of the chamber is attained. The residue is thrown to the side and runs to the bottom of the chamber, from which it flows through a seal into the bitumen receiver. The vapours pass over into a condenser and thence into a receiver. For waxy crudes it is necessary to use hot water in the condenser. It is important to design the apparatus for the minimum possible contact time to avoid cracking, and particular care should be directed towards keeping the size of the bitumen seal to a minimum. The flash chamber and bitumen seal are guarded against heat loss by means of an electrically-heated and well-lagged air-oven. Temperatures are measured by means of thermocouples situated in the preheater, exit end of the heating tube, flash chamber, and air-oven. Pressures are measured at the vacuum manifold, flash chamber, distillate receiver, and bitumen receiver. A capacity vessel should be attached to the vacuum manifold as an aid to steady operation.

The apparatus should be designed to operate at throughputs of 300 to 700 ml of feed per hour, pressures down to 1 mm Hg, and maximum temperatures of 750° F. By varying the operating temperatures a series of bitumens can be prepared, enabling curves connecting yield with penetration, and penetration with softening point and other properties to be established. The operating data may also be used to provide flash curves for the feed-stock at any required pressure.

Standard Assessment

The principles to be followed in the laboratory assessment of crude oil have been set out above, indicating the methods to be adopted to obtain sufficient data to enable a refiner to judge whether a crude oil is suitable for a given refinery, or to indicate which changes would have to be made in his refinery schemes. In addition, it is desirable that the yields and properties of definitely specified distillates and residues be given, so that as data accumulate a direct comparison is available between the crude oils examined. The following is a typical example of suitable fractions for yield and property assessments :—

Gas, to 60° F
Gasoline, 60°–300° F
Kerosine, 300°–450° F
Gas oil, 450°–650° F
Heavy gas oil, 650°–700° F
Residue, above 700° F

The following properties of the crude oil and products should be quoted.

METHODS OF TEST

	Crude oil.	Gasoline.	Kerosine.	Gas oils.	Residue.
Specific gravity .	I.P. 59	I.P. 59	I.P. 59	I.P. 59	I.P. 59
Distillation . .	I.P. 24	I.P. 123	I.P. 123	I.P. 123	—
Reid vapour pressure	I.P. 69	I.P. 69	—	—	—
Sulphur . . .	I.P. 61	I.P 107	I.P. 107	I.P. 107	I.P. 61
Mercaptan sulphur .	—	I.P. 104	I.P. 104	—	—
Octane number .	—	I.P. 44	—	—	—
do + T.E.L. . .	—	I.P. 44	—	—	—
Aniline point . .	—	—	I.P. 2	I.P. 2	—
Aromatic content .	—	—	I.P. 3	—	—
Diesel index . .	—	—	—	I.P. 21	—
Smoke point . .	—	—	I.P. 57	—	—
Pour point . .	I.P. 15	—	—	I.P. 15	I.P. 15
Viscosity: at 70° F .	I.P. 71	—	—	—	—
100° F .	—	—	—	I.P. 71	Extrap.
140° F .	—	—	—	—	I.P. 71
210° F .	—	—	—	—	I.P. 71
Carbon residue. .	I.P. 13 & 14	—	—	—	I.P. 13 & 14
Asphaltenes . .	I.P. 6	—	—	—	I.P. 6
Water and sediment .	I.P. 75	—	—	—	—
Salt content . .	I.P. 77	—	—	—	—
Ash . . .	I.P. 4	—	—	—	—

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OBITUARIES

ARTHUR GEORGE VALE BERRY

ARTHUR GEORGE VALE ("PETER") BERRY, Fellow of the Institute of Petroleum, died in his sleep on Friday, September 1, and was buried at Hawarden (Flintshire) on Tuesday, September 5, 1950. He was born May 28, 1886, and commenced his long career in the petroleum industry in the laboratories of Sir Boverton Redwood in 1901. He studied chemistry and gas engineering as a part-time student at Finsbury Technical College, and in 1914 had become one of Redwood's senior chemists. He left Redwood's laboratories in 1917 to become chief chemist of the Petroleum Research Laboratory under the control of the Ministry of Munitions and the Admiralty, a post he vacated in 1919 on his appointment as chief research chemist to Trinidad Leaseholds Ltd. On his retirement in 1946 from tropical service with Trinidad Leaseholds Ltd., he was loath to leave the industry, and gladly accepted an appointment with Lobitos Oilfields Ltd., as superintendent of research and development, a post he occupied until his death.

He was one of the earliest members of the Institute of Petroleum, his application for Associate Membership being dated March 30, 1914. He was transferred to Membership in 1918, and to Fellowship in 1939. He was a Founder Member, and served on the original Committee of the Trinidad Branch. On his return to England he joined the Stanlow Branch, and became honorary treasurer of the Branch in 1948. He was elected an *ex-officio* member of Council in 1950. Although he was the author of several papers, the greater part of his research work has remained unpublished. He carried out a series of investigations into the properties of asphalts, the manufacture of air-blown asphalts from cracked residuum, and the properties and production of petroleum coke. He investigated the phenolic constituents of petroleum, and developed insecticides and fungicides based on these compounds. He was particularly interested in the constitution of naphthenic acids, and developed wood preservatives and other products manufactured from naphthenic acids extracted from Trinidad petroleums. During his career he devoted much time and attention to methods of analysis of petroleum products, and in his later years he served on the Standardization Committee and was Chairman of the Crude Oil Sub-Committee. He was a Fellow of the Royal Institute of Chemistry and of the Chemical Society.

"Peter" had a brusque manner, and at times his colleagues found him rather difficult to approach, but he had a kindliness and an essential friendliness which, once the barrier of his natural shyness had been overcome, made him a valued friend. Children loved him, and "Uncle Peter" was always in great demand at their parties. Above all, Peter was a person of outstanding character, and his passing will be mourned by many friends and former colleagues in Trinidad as well as by a wide circle of new friends in the Stanlow Branch.

F. MORTON.

LOUIS PINEAU

Louis Pineau, Commander of the Legion of Honour and an Honorary Member of the Institute of Petroleum, was born on January 25, 1888, and entered Saint Cyr in 1907. During the first world war he first served in the infantry, was twice mentioned in despatches, and was appointed a chevalier of the Legion of Honour for bravery. His wounds rendered him unfit for further active service, and in 1916 he passed the examination for the commissary. In this service he held various important posts, and was eventually entrusted with the organization and management of the general reserve of stores at Mignères–Gonderville.

While in this position he was selected by M. Henry Beringer, then General Commissioner for Spirits and Fuels at the Ministry of War, to take over management of imports and purchases of the petroleum monopoly regime. Until the end of this regime in 1921 he carried out the general management of purchases and the disposal of war materials, and received the congratulations of the Inspector General of Finances.

In 1925 he was appointed director of the Office Nationale des Combustibles Liquides, a post which he occupied until relieved of it by the Vichy Government in 1940. In this capacity he conceived and organized the activities of this essential organ of French petroleum policy. In 1937 he created the Centre de Recherches du Pétrole du Midi (later the Regie Autonome des Pétroles). The first productive well was brought in at Saint Gaudens in 1939 and was one of those in the group still known as " Louis Pineau wells."

Since 1945 he was particularly active as president of the Société d'Encouragement pour l'Industrie Nationale, and from the beginning of 1947 acted as technical consultant to the Union des Chambres Syndicales de l'Industrie du Pétrole.

He was honorary president of the Association Française des Techniciens du Pétrole, president of the Amis de Saint Cyr, a vice-president of the Maison de la Chemie, and president of the Permanent Council of World Petroleum Congresses.

In the scientific sphere, Louis Pineau was well known and respected in France and abroad for his work and researches on fuels and lubricants. His loss will be greatly deplored in all industrial circles and particularly in the petroleum industry.

E. Blimer

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Oilfield Exploration and Exploitation

Geology

2383. Internal structure of shoestring sands. O. F. Evans. *World Oil*, 1.7.50, **131** (1), 66.—The long and narrow shoestring sands of Kansas and Oklahoma have generally been considered to be buried spits or bars. Little attention has been given to the internal structures of such sands, partly due to the difficulty of obtaining oriented cores. Several other types of deposit are long and narrow, such as beach ridges, subaqueous dunes, balls, and channel deposits.

Beach ridges often reach a height of several feet, and may serve as oil reservoirs. Material is usually sand, but boulders and gravel may be present locally. The structure is complicated, and in general is made up of a large number of relatively thin overlapping sand lenses of various sizes. The steeper slope is seawards. Other beach structures related in their mode of formation to ridges are spits, bars, tombolos, and probably barrier beaches.

Other types of ridges parallel to the shoreline are low and ball structures. These are formed by plunging breakers, and should be relatively easy to identify by their shape and arrangement. When buried, the upper contact should appear as a series of structural ridges and troughs. Under certain conditions balls may serve as foundations for spits and bars.

Channel sands, often extensively cross-bedded, may act as oil reservoirs. They are deposited in narrow straits at the entrance to bays or inland seas, or between islands and the mainland. The Verdan sandstone of Oklahoma is of this type.

Little is known of the irregular masses of sand that lie on the sea floor in moderately deep water, such as those in the English Channel and North Sea. They may be formed by strong alternating tidal currents. C. A. F.

2384. A projection of oil discovery . . . 1949–1965. G. R. Hopkins. *Petrol. Tech.*, June 1950, **2** (6), 6–9.—Generally oil gravity (A.P.I.) increases with depth or age of the formation. The Eocene figures are somewhat anomalous, but this may be due to a greater general producing depth than is the case for the Cretaceous crudes. The same explanation may hold for the anomaly associated with the Cambrian crudes. For oil obtained from a single geological system there is a broad trend showing increase in gravity with increase in depth. For the U.S. oilfields known at the end of 1949 the average size shows a tendency to diminish with age, rapidly at first and then more slowly, excepting the Permian and the Upper Cretaceous when East Texas is included. The Permian oils have lower than average gravity and higher than average sulphur content, as well as limestone reservoir. It is considered that sulphur protects crudes by inhibiting their ripening and thus favouring escape. Brooks has admitted that catalysis of heavy crudes to light crudes could occur at 140° F. There is a broad inverse relationship between gravity and sulphur content.

Despite an expanding wildcat programme, fewer and fewer large fields have been found over the past ten years in the U.S.A. It seems doubtful whether the preliminary estimates of ultimate recoveries for the fields will collectively be increased by 50%. As fields become smaller, the first wells prove a greater proportion of both total and proved reserves.

Since the war the numbers of exploratory wells has increased yearly, together with the average footage and the costs.

Secondary recovery will expand, but may add little to reserves. Unitization should, however, have a good effect if it can be applied. Close spacing would be too expensive in deep fields, and in shallow fields the reserves available by this device have been included. Improvements in primary discovery methods alter the time at which oil is obtained, but not necessarily the total recoverable.

Assuming that the present volume of discovery continues to 1965, it is estimated that domestic output will rise to a peak slightly above 6,000,000 b.d. in 1955 and then fall to about 5,000,000 b.d. in 1965, at which date the demand by continued rise will be about 8,000,000 b.d. The figures are compared with those produced by Schroeder and Solliday, who, respectively, predict deficiencies of 4,274,000 b.d. and 2,395,000 b.d. in 1965. G. D. H.

2385. Distribution and thickness of the Queenston shale in the North Appalachian Basin. G. Rittenhouse. *Producers' Monthly*, Mar. 1949, **13** (5), 29.—A brief description is given of the Queenston shale, accompanied by an *iso*pachous map prepared from sample examinations. The importance of this shale as a marker in the event of deeper drilling is mentioned. A. J. H.

2386. Oil and gas prospects in Alabama. W. B. Jones. *World Oil*, 1.7.50, **131** (1), 57.—Two wells recently completed in Alabama have found oil and gas.

M. W. Davies *et al* 1, in the southern tip of Clarke County, discovered the second oilfield in Alabama. It initially produced 84 b.d. of 14° oil from the Upper Cretaceous Tuscaloosa, which is productive elsewhere in the Gulf Coast area. The structure is believed to be an anticline with its axis parallel to an extension of the Jackson fault.

Lewis 1-A, 4 miles southwest of Hamilton, Marion County, had a potential of over 2 M.c.f. gas/day from Mississippian Bethel Sandstone. The structure is probably a northwest–southeast trending warp, perpendicular to the axis of the Appalachian geoanticline. Good oil shows were found above and below the gas pay.

There are now forty-two producers in the Gilbertown field. Production is from a zone close to a fault plane on the north flank of the Hatchetigbee anticline.

The area showing the best possibilities of developing production is in the neighbourhood of the McIntosh salt dome, the Gilbertown field, and the Clarke County well. Sand lenses along the outer margin of the province may be productive.

An outline map showing the oil and gas potentialities of Alabama is included.
C. A. F.

2387. Tests indicate new pool. Anon. *Petrol. Engr*, July 1950, **22** (8), B-86.—Rankin 82–31, in Kern County, California, initially flowed 3500 b.d. of 35·8° oil and 1300 M.c.f. gas/day. The well is about half a mile south of the Telegraph Hills field.
C. A. F.

2388. Geology of Hungry Valley area, Southern California. J. C. Crowell. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 623–46.—Hungry Valley is in the Transverse Ranges of California about 55 miles northwest of Los Angeles. The general geological structure of the Hungry Valley area consists of a graben overfilled with Ridge Basin sediments and bordered on the southwest by the San Gabriel fault zone. The basement rocks bounding the graben west of the San Gabriel fault have been displaced relatively towards the southeast by movement on the Frazier Mountain and Dry Creek thrusts.

During late Tertiary time a thick section of coarse and fine continental clastics accumulated in Ridge Basin. Deposition was concurrent with movement on the San Gabriel fault zone which delimited Ridge Basin on the southwest. Movement on this fault ceased in late Pliocene time, and the younger sediments overlapped southwestward across the fault and on to a pediment cut into the crystalline basement. The low-angle Frazier Mountain thrust moved in the Pleistocene relatively southeastward across the veneer of sediments on the pediment and in part on to the thick Ridge

Basin deposits. Subsequently the thrust, veneer of sediments, and pediment were folded and faulted along an east–northeast trend, whereas the thick sediments in Ridge Basin were folded along trends nearly at right angles to this and subparallel with the basin margins. At this time the San Gabriel fault zone was reactivated in the southern part of the area. E. N. T.

2389. Drills California discovery. Anon. *Petrol. Engr*, July 1950, **22** (8), B-84.—Shell-Fee 63x–23 produced 500 b.d. of 15·3° oil from 2267 to 2360 ft. The well is 3½ miles northwest of the Antelope Hills field. C. A. F.

2390. Structural features of western Antelope Valley, California. J. H. Wise and S. F. Fine. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 1647–58.—Antelope Valley lies partly in Kern and partly in Los Angeles counties in southern California, about 60 miles from the coast and almost midway between the cities of Bakersfield and Los Angeles. Commonly called the western tip of the Basin and Range province, it is a triangular, alluvium-floored valley bounded by the rugged Tehachapi Mountains on the northwest and the equally precipitous San Gabriel Mountains on the southwest.

It is underlain by Tertiary marine and non-marine sediments and volcanics, and bounded by ranges composed of crystalline rocks. Its form is outlined by the northeast-trending of Garlock fault zone and the southeast-trending San Andreas rift, both major lines of weakness. Between these faults, smaller faults of northeast and northwest trends break the rocks of Antelope Valley into at least a dozen tilted blocks. Left-lateral movement is demonstrated on several of the smaller faults which branch from the Garlock, and it is suggested these may be the recent offspring of the Garlock and that the main Garlock fault zone is "dead" in this area, though continuing active on the northeast in the Mojave Desert area.

Folding played a minor role in the structural development of the basin, though there are a number of small anticlines in the Tertiary rocks at the west edge of the valley. The predominance of non-marine sediments makes it unlikely that any oil or gas will be found in commercial quantities. E. N. T.

2391. Old field shows new rich sand. Anon. *Petrol. Engr*, July 1950, **22** (8), B-80.—Jerman and Bartell-Webb 1, in the southeastern extension of the Signal Hill field, California, produced 1200 b.d. of 28·8° oil and 1500 M.c.f. gas/day from 5900 to 6400 ft. Gasoline content of the gas was 1·68 gal/M.c.f.

The well has proved an extensive area south of the Signal Hill fault, and there are twelve wells being drilled in the adjacent area. C. A. F.

2392. Late Paleozoic and Mesozoic history of Colorado and adjacent areas. R. L. Heaton. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 1659–98.—This paper consists essentially of a revision of paleogeographic data published in 1933 and 1937. Since the so-called Ancestral Rockies had a profound effect on Late Paleozoic and Mesozoic sedimentation in an area extending considerably beyond the boundaries of Colorado, the areas discussed include much of the Rocky Mountain region.

The maps accompanying this paper are the result of an approach from the standpoint of the historical sequence of events, and, in some instances, there is necessarily an overlap of lithologic units.

The revisions in Permian and Pennsylvanian paleogeography are comparatively slight, and consist mostly of the elimination of some islands in Utah, a union of the Zuni and Defiance positive elements in New Mexico, and some changes along the edges of the Front Range and San Luis positive areas.

Only slight revisions are made in the Triassic maps, but there are considerable changes in Jurassic maps. The Navajo-Nugget sandstone is extended much farther east across Wyoming and questionably into the Black Hills of South Dakota. The Carmel–Twin Creek map is also extended, recent work having established the presence of Middle Jurassic and early Upper Jurassic beds over a larger area than that shown on previous maps. The sandstone facies of the Entrada becomes more shaly, silty, and predominantly red towards the west and north. The Curtis marine beds and their equivalents are shown as having a marginal extension east and south, consisting of evaporites and shales. The Morrison fresh-water deposits are shown as extending farther north and east than in previous maps.

Author's former maps of three stages in the Cretaceous are revised, using data from various sources. E. N. T.

2393. Make strikes in Utah, Colorado. Anon. *Petrol. Engr*, July 1950, **22** (8), B-82.—A well drilled 5 miles southeast of Roosevelt, Uintah County, Utah, made 480 b.d. from the Green River.

In Colorado, a wildcat in the Armstrong area of Logan County, was completed for 120 b.d. C. A. F.

2394. Makes gas find in Colorado. Anon. *Petrol. Engr*, July 1950, **22** (8), B-84.—A wildcat in the Ignacio area of La Plata County blew gas from 2440 ft and flowed approx 5 M.c.f. gas/day. The well is northeast of the Barker Creek field and north of the Blanco basin–Kutz canyon gas-producing areas. C. A. F.

2395. Finds field at 14,000 ft. Anon. *Petrol. Engr*, July 1950, **22** (8), B-86.—1 Alice B. Rozas, 2 miles northeast of Opelousas, St Landry Parish, Louisiana, on test flowed 225 b.d. of 49·4° oil and 2375 M.c.f. gas/day from 11,412 to 11,422 ft. C. A. F.

2396. Extends Nebraska pool. Anon. *Petrol. Engr*, July 1950, **22** (8), B-82.—1 Dorman, in Cheyenne County, on test flowed 3,895 M.c.f/day of wet gas from 4656 to 4669 ft. Static bottomhole pressure was 1125 p.s.i.

The well has extended the Huntsman field 2 miles to the south. C. A. F.

2397. Active interest is shown in oil possibilities of Nevada. Anon. *World Oil*, 1.7.50, **131** (1), 30.—Substantial leases have been acquired in the eastern half of Nevada, and numerous structures have been mapped. There are seeps in some areas. Pennsylvanian, Mississippian, and older rocks, which range in depth from 4000 to 14,000 ft, may be productive.

A wildcat is being drilled in the Pancake Range, about 45 miles west of Ely in White Pine County. C. A. F.

2398. Oklahoma gets two new discoveries. Anon. *Petrol. Engr*, July 1950, **22** (8), B-86.—1 Pope, in Coal County, Oklahoma, flowed 12 M.c.f. gas/day, which on separation made 125 b.d. distillate.

1 Wilson Estate, on test made 4928 b.d. of 38·2° oil and 724 M.c.f. gas/day from dolomite at 6069–6116 ft. C. A. F.

2399. The McDonald oil field—Allegheny and Washington counties, Pennsylvania. R. I. Ingham. *Producers' Monthly*, Feb. 1949, **13** (4), 29.—This review of the McDonald field one of the largest and most prolific oilfields in the Appalachian basin, deals essentially with the geological background.

There exist two prominent structures: the Wildwood anticline and the Mt Nebo syncline. The relation between the age of some of the cross trends and the types of sedimentation is discussed. Although essentially a stratigraphic type of field, the structure in some instances influences the accumulation of oil and gas. Ten oil sands exist, but over 90% of the production is obtained from the Gordon and Fifth Sands.

As in the case of many of the older fields, there is insufficient knowledge of the reservoir to permit the satisfactory planning of a secondary recovery project. The McDonald field was first discovered in 1890.

Five maps and references. A. J. H.

2400. Drills Midland wildcat. Anon. *Petrol. Engr*, July 1950, **22** (8), B-86.—Parks 2, 12 miles southwest of Midland, Midland County, Texas, on test flowed 3000 b.d. of 53·9° oil from the Ellenburger at 12,955 ft. The well is 13 miles north of the Pegasus field. C. A. F.

2401. Indicates Canada strike. Anon. *Petrol. Engr*, July 1950, **22** (8), B-84.—1 Whitelaw, about 35 miles west of Peace River, northwestern Alberta, flowed 7020 M.c.f. gas/day from 3371 to 3468 ft and from 3855 to 3905 ft recovered 3350 ft of 24° oil. Pay is between the Madison and Devonian. C. A. F.

2402. Make Canadian gas strike. Anon. *Petrol. Engr*, July 1950, **22** (8), B-84.—1 Turin, in the Tabor area, 110 miles southeast of Calgary, flowed 8 M.c.f. and 5 M.c.f. gas/day from the Jurassic Ellis, and 1330 M.c.f/day from the Madison sand. The Devonian is to be tested. C. A. F.

2403. Four producers drilled in Chile during 1949. Anon. *Petrol. Engr*, July 1950, **22** (8), B-78.—Thirteen wells were completed in Chile in 1949, four of which produced oil. One 55,000-brl tank and two 5000-brl tanks were completed at the field and two 80,000-brl tanks at Caleta Clarence, the embarkation port. A pipeline was laid from the field to the port.

Restricted Chilean production is 2000 b.d. C. A. F.

2404. Complete Colombian well. Anon. *Petrol. Engr*, July 1950, **22** (8), B-80.—2 Tetuan, on the Caribbean coast, flowed 1000 b.d. of low-gravity oil.

1 Tetuan found a pool in the Upper Magdalena Valley area, northwest of Ortega. C. A. F.

2405. Creole's Alturitas 1. Anon. *World Oil*, 1.7.50, **131** (1), 218.—Alturitas 1, 80 miles southwest of Maracaibo, Venezuela, on preliminary test flowed 1200 b.d. on ¾-in choke from the Eocene. Total depth was 17,039 ft. Mechanical difficulties prevented the testing of the Cretaceous limestone. C. A. F.

2406. U.K. has 400 oil wells. Anon. *Petrol. Engr*, July 1950, **22** (8), B-79.—There are approx 400 wells in England and Scotland, some of which give moderate production. Peak production of 112,700 tons was reached in 1943. C. A. F.

2407. Drills German well. Anon. *Petrol. Engr*, July 1950, **22** (8), B-84.—8 Lingen-Dalum, ½ mile east of the Dalum field, Emsland, produced 380 b.d.

In the Dalum field, L63 flowed approx 125 b.d. Good production was obtained in L73. C. A. F.

2408. Stratigraphic distribution of evidences of bituminous substances in Turkey. C. E. Tasman. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 1718–28.—Nearly fifty occurrences of oil, gas, and asphalt in Turkey are catalogued. Their distribution in the geologic column is noted. The Tertiary is credited with thirty-three, Mesozoic with eighteen, Paleozoic with four indications, and the number of seepages found in igneous rocks is seven. An interesting evidence of oil in the sea is mentioned.

In this discussion, instances of the occurrence of tars and other pyrogenous products of distillation are not considered. Also, no reference is made to the localities where bituminous shales are found. Sulphuretted hydrogen emanations, at times indirectly related with oil, and non-hydrocarbon-gas seepages are likewise omitted. This article covers only the evidences of oil, gas, native asphalt, and asphaltites. E. N. T.

Geophysics and Geochemical Prospecting

2409. Clay minerals of Laramie formation, Golden, Colorado, identified by X-ray diffraction. A. J. Gude. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 1699–717.—Clay minerals are distributed in varying amounts and associations throughout the sedimentary geologic column. Identification of these clay minerals can be valuable to stratigraphers and sedimentologists. However, identification of the clay minerals is not readily done by ordinary techniques. The X-ray powder-diffraction method is ideally suited to the study and analysis of clay minerals.

A study of the mineralogical and lithological distribution and association of clay minerals by the X-ray diffraction-powder method is described. The geologic work was done at Golden, Colorado, where a complete section across the Upper Cretaceous Laramie formation was mapped, measured, and sampled in detail.

It was found possible to subdivide the Laramie into three stratigraphic intervals based on the clay-mineral assemblages identified by X-ray patterns. The upper formation boundary was confirmed, and the lower boundary was raised 65 ft from interpretation of the X-ray data.

It is concluded that X-ray diffraction can be used to advantage by geologists, particularly where mixtures of clay minerals and other fine sediments cannot be handled by other methods. E. N. T

2410. Electronics applied to oil exploration. B. M. Balter. *World Oil*, 1.7.50, **131** (1), 72.—Laboratory and field experiments have been carried out to determine the feasibility and efficiency of applying electronic principles to determine the hydrocarbon content of favourable structures with a reasonable degree of accuracy. The technique is based on the insulating quality of hydrocarbons. The recording instruments create an electronic field which is distorted by insulated bodies in direct proportion to their depth and amount of contained hydrocarbons. The observed results are measurements of that distortion, expressed as " voltrons."

It has been found that the technique is useful in conjunction with conventional exploratory methods to reduce the hazards involved in oil search. C. A. F.

2411. Patent. S. A. Scherbatskoy, assr to Well Surveys Inc. U.S.P. 2,507,351, 9.5.50. An apparatus for transmitting data from a well-surveying subsurface instrument to a recording system on the surface. C. F. S.

Drilling

2412. Selective S.P. logging. H. G. Doll. *Petrol. Tech.*, May 1950, **2** (5), *A.I.M.M.E. Tech. Paper No.* 2850, 129–42.—In logging the permeable beds enclosed in thick, highly resistive beds the ordinary S.P. log fails to define the former adequately. In order to overcome this difficulty the technique of selective S.P. logging has been introduced. This employs auxiliary electrodes placed above and below, and near the measuring electrode. Their potentials are controlled, and thereby the flow of S.P. current along the well bore is modified to counterbalance the effect of highly resistive strata. By this means a close approximation to the static S.P. can also be obtained.

Several procedures and arrangements are adopted in order to obtain the max information, and these, together with the underlying principles, are explained. Several field examples are described and discussed.

Selective S.P. logging gives an accurate determination of the permeable beds, even in highly resistive formations, except when the salinity of the mud is extremely high. G. D. H.

2413. Particle-type well logging. J. E. Banks. *Bull. Amer. Ass. Petrol. Geol.*, **34** (8), 1729–36.—A multi-column log form is proposed for recording and analysing the abundant lithologic information available from well samples. The recording method is unique in that particle types instead of rock types are plotted. Illustrations are presented and the method of plotting explained.

The necessity for an amplified log form arises from the increased use of lithology in analysing the oil possibilities of a geologic province or a local structure. The value of detailed lithology in many oil provinces is evidenced by the almost universal use of microscopes in the preparation of sample descriptions. As a result of this emphasis on lithology, the familiar rock-type sample log may be replaced with a particle-type log because, like the hand-lens, the narrow column, rock-type log has limited resolving power. E. N. T.

2414. Formation clay minerals and electric logging. L. O. Bacon. *Producers' Monthly*, Jan. 1949, **13** (3), 18.—S.P. logs are used for the indication of permeable zones, but the results of tests show that there is little possibility of determining quantitatively the porosity and permeability of formations.

The paper deals with electro-chemical potentials, describing methods of measurement of self-potentials in a model well and of diffusion potentials of natural and synthetic cores, and clays. The clays were contained in a glass cylinder, separated from the electrolytes by parchment at the ends. Preparation of the clays is described, and base-exchange and formation potentials are discussed.

Results are expressed graphically. A. J. H.

2415. Laboratory tests of electrolog resistivity interpretations. J. C. Cook. *Producers' Monthly*, Jan. 1949, **13** (3), 25.—In theory the porosity and permeability may be determined by the measurement of electrical resistivity of a formation. The resistivity is increased when the formation is invaded by fresh water, and is a function of the porosity, and the extent of the invasion is a measure of the permeability.

The results of the experiments described are inconclusive; the variation of the calculated porosity from the known values is as great as the difference in porosities of the various cores under test.

The circuit and logging probe are described with aid of diagrams, and results shown graphically. A. J. H.

2416. Streaming potentials in electric well logging. M. T. Kozary. *Producers' Monthly*, Feb. 1949, **13** (4), 14.—The standard streaming potential equation indicates that the potential is independent of the length and cross-sectional area, but dependent on the pressure and the resistivity of the electrolyte. The experimental work was designed for the purpose of verifying this relation, and was conducted on capillaries of various sizes, on a bundle of capillaries, and on consolidated and unconsolidated cores. The effect of turbulent flow on streaming potential is also considered. A closer approximation to field conditions was obtained in tests using oil–water mixtures: flooding an oil-saturated core with an electrolyte, and flooding the core with varying proportions of oil–water mixtures.

It is stated also that certain salt complexes may suppress or even reverse the sign of the streaming potential. The series of experiments are described fully with the aid of diagrams and graphs. A short summary is given. A. J. H.

2417. Reservoir characteristics and electric logging. S. J. Pirson. *Producers' Monthly*, Feb. 1949, **13** (4), 22.—Some of the basic formulæ suitable for the calculation of water saturation, porosity, and permeability of formations from regular and special electric logs are considered. The determination was based on the system of fresh-water invasion of formations.

In the calculation of porosity the formation was likened to three coaxial cylinders, representing the well, the invaded zone, and the reservoir rock unaffected by the invasion of the water. Porosity and permeability were determined from a series of graphs.

Calculation of water saturation was simplified by use of nomographs, one of which is reproduced.

The inconsistency of results is attributed in part to insufficient records of core analyses, and the variation between the absolute air permeability and the effective permeability to water. A. J. H.

2418. The force exerted by surface waves on piles. J. R. Morison, M. P. O'Brien, J. W. Johnson, and S. A. Schaff. *Petrol. Tech.*, May 1950, **2** (5), *A.I.M.M.E. Tech. Paper No.* 2846, 149–54.—The effects of waves of small amplitude on a single isolated pile without bracing have been examined theoretically, and it is inferred that the drag force decreases with distance below the surface more rapidly than does the inertia force. The max force is developed before the crest passes, but not simultaneously at all points, while the relative importance of the inertia force increases with the ratio of pile dia to wave height.

Laboratory studies were based on the equations previously derived, a model pile, hinged at the bottom with the necessary restraining force being measured at a known moment arm above the hinge. Means were also provided for recording the wave profile and velocity. It was evident that the max force produced by a breaker or incipient breaker greatly exceeds the force corresponding to the orbital velocity which, under breaking conditions, is the wave velocity. The impact force was of short duration, and its impulse may not be great. The impulsive force represents the ultimate development of the accelerative force, and is produced by the steep wave front and large horizontal acceleration at the front of the breaker. This impulsive force greatly exceeds the drag force computed from the particle velocities of the breaker. G. D. H.

2419. Air powered tubing wrench. G. G. Bauer. *Producers' Monthly*, Jan. 1949, **13** (3), 34.—The purpose of this machine, developed by Neal K. Wilson, is to eliminate hand-power wrenching. Its design is based on the principle of the split gear.

The wrench is driven by air-power, thus fulfilling the requirements of high torque, variable speed, and reversibility. Manipulation of the controls may have the same effect as the hammering on the collar, while breaking the joint.

Operation of the unit is fully explained. A. J. H.

2420. Application of Electrodrill coring method in secondary recovery. A. Arutunoff. *Producers' Monthly*, June 1949, **13** (8), 29.—The development of a coring system which combines the efficiency of a rotary system and a diamond core bit with the economy of cable suspension is welcomed. The Electrodrill equipment is easily transportable, and includes essential features such as circulating pump and bailer for the removal of cuttings. The assembly is described.

The Electrodrill system may be operated under any suitable head of liquid, and has the advantage of allowing the coring to continue under the pressure of the formation, thus reducing core contamination. Geological information also is more reliable in view of the higher efficiency of core recovery. A. J. H.

2421. Patents. M. E. True, assr to Standard Oil Development Co. U.S.P. 2,507,127, 9.5.50. Automatic drill pipe elevator.

W. R. Stinnett. U.S.P. 2,507,230, 9.5.50. Weight-controlled seismographic combustion deflection.

C. J. Keim, assr to Oil Well Supply Co. U.S.P. 2,507,256, 9.5.50. Well drilling apparatus. C. F. S.

Production

2422. An electronic analog computer for solving the flash vaporization equilibrium equation. F. W. Bubb, R. G. Nisle, and P. G. Carpenter. *Petrol. Tech.*, May 1950, **2** (5), *A.I.M.M.E. Tech. Paper No.* 2853, 143–8.—A seven-component computer has been constructed for solving the equations for vapour–liquid equilibrium im multi-component systems. Each unit is a resistance network with a voltage-matching servo-mechanism, and each provides an output voltage proportional to the mol-fractions for vapour and liquid phases. These voltages are summed and matched with a reference voltage to provide the solutions.

The basic problem is stated, and the principle of the computing unit is described.

The computer can be used for calculating optimum separator operating conditions, the evaluation of reserves (under simplifying assumptions) and for natural-gasoline plant calculations. Sample computations are given, and the results compared with values obtained by trial-and-error methods. The computed values have a probable error of 0·002 in the first approximation, but an interpolation method can be used to obtain a probable error of only 0·0002. G. D. H.

2423. Anomalies in the measurement of wetting liquid pressure gradients. W. Rose and B. Greifer. *Petrol. Tech.*, June 1950, **2** (6), 10–11.—Occasionally negative pressure gradients have been noted in the study of mixture flow in cores. If a leak occurs in the lines connecting the core to either side of the differential manometer, errors exceeding 100% may arise in the estimation of the wetting-liquid pressure gradient, even though the leak is so small that it would tend to be obscured by evaporation effects. Up-stream side leaks may give low or negative pressure gradients, while down-stream side leaks have the opposite effect. Multiple leaks would give some measure of compensation.

The problem is examined analytically, employing an electrical analogue of the flow system, and a numerical example is given. G. D. H.

2424. Progress report on multiphase-flow studies. J. H. Henderson and A. H. Meldrum. *Producers' Monthly*, Mar. 1949, **13** (5), 12.—The apparatus is similar to that used in the initial studies of relative permeability, but the use of longer test sections was introduced in an effort to reduce end-effects.

One modification in the experimental procedure was the initial saturation of the core by oil, complete saturation thus being more easily obtained than with brine. Although detrimental to conductivity experiments, it was more important that the saturation, determined on a gravimetric basis, should have been complete.

The two main points of interest were the dynamic behaviour of each phase and the equilibrium saturation between the phases.

Full explanation is given with the eight graphs reproduced. Second readings were taken in an attempt to verify results, but in each case a slight variation was obtained. This was attributed in part to the apparatus and also to the possibility of incomplete initial saturation. A. J. H.

2425. The treatment of water for flooding purposes. A. R. Ellenberger. *Producers' Monthly*, June 1949, **13** (8), 19.—The sources of water used in secondary recovery projects include streams, springs, wells, and water produced with oil. The necessity of using the more convenient supply of water creates problems in treating which differ from field to field. The aim of all treating systems is the chemical stability of the treated water. The design of the treating plant must take into account dissolved gases and salts, and organic matter.

The removal of iron, manganese, and hydrogen sulphide, and the elimination of algæ and other organic matter may be effected by chlorination. This may be by direct addition of chlorine or in the solution of sodium or calcium hypochlorite. Aeration plants are also used, but inevitably the oxygen content is increased, so permitting the corrosion of iron. De-aeration is therefore a necessary secondary stage. The use of complex phosphates is also mentioned.

Filtration systems are necessary for the production of a clear water, and the efficiency of these plants is maintained only by frequent back-washing.

The advantages of water-treating are illustrated by the comparison of production graphs. A. J. H.

2426. West Red River field, Tillman County, Oklahoma. H. B. Hill, K. H. Johnston, T. L. Coleman, and T. M. Seward. *Producers' Monthly*, Apr. 1949, **13** (6), 27.—The West Red River field, first discovered in 1919, has been produced under various programmes, including vacuum, repressuring, and water injection. Although no increase in production was observed as a result of the water-injection scheme of 1940, it was hoped to develop a peripheral flooding programme to give an increased production in the region of 10% of the ultimate recovery of 7·5 million brl of oil.

The structure of the field, which is a flat dome with three subsidiary domes situated on the major east–west axis, and the producing zones are briefly described with the aid of structural, isopachous, and sectional maps.

Production data are given in graphical and tabular form.

The importance is stressed of being well acquainted with the former production history of the field in order effectively to plan future secondary recovery projects. A. J. H.

2427. Petrographic evaluation of porosity measurement. J. C. Griffiths. *Producers' Monthly*, Apr. 1949, **13** (6), 38.—The petrographic evaluation of porosity is dependent primarily on the accuracy of the determination of the porosity. The experimental data is itself subjected to experimental and sampling errors.

The two aspects of the subject are discussed. The method of determining and calculating the porosity is described, with emphasis on the statistical approach to the results. Five samples of rock are considered, and the individual petrographic interpretations are given.

Results are given in five tables and three specimen data sheets. A. J. H.

2428. Petrography and reservoir potentialities of the Nittany Dolomite. R. L. Folk. *Producers' Monthly*, May 1949, **13** (7), 35.—The classification of the rock has been based on crystallinity, this being considered the more fundamental feature.

Examination of a typical section of the Nittany Dolomite has shown that six main porosity groups exist. The important type is intergranular porosity, since this is more directly connected with porosity characteristics and reservoir potentialities. A. J. H.

2429. Some aspects of porosity and cementation. M. A. Rosenfeld. *Producers' Monthly*, May 1949, **13** (7), 39.—The paper is introduced by a summary of the variables affecting the porosity of sediments. The six factors were believed to be interdependent, but the presence of chemical cementation is such as to affect primarily the porosity of the rock. The minus-cement porosity was considered, therefore, to be of importance, and a laboratory technique was developed to determine this value.

The graphical relationship between minus-cement porosity and measured porosities of Bradford and Venango Sands shows that, while decreasing the porosity, the effect of chemical cementation is independent of the other factors. In the case of Mid-Continent Quartzite, however, it was shown that a definite relationship existed.

Certain hypotheses suggested for further development are summarized and references given. A. J. H.

2430. Note on the relation between capillary pressure and interfacial tension. E. L. Powers and H. G. Botset. *Producers' Monthly*, June 1949, **13** (8), 15.—Estimations of interstitial water content of oil reservoirs have been made by the restored-state method of capillary pressure measurement. The fundamental equation relating capillary pressure to interfacial tension would suggest, therefore, that the water saturation of a sand may be directly affected by the interfacial tension.

For capillary pressure measurements four liquids were chosen, chloro-ethane, kerosine, Bartlesville Crude, and turpentine, having interfacial tensions ranging between 32 and 8·5 dynes/cm. From the graph, it was shown that the interfacial tension showed no relationship to min water saturation; thus, the latter may have been a characteristic of the sand. The experimental data showed, however, that the rate of displacement of water was greater with liquids of low interfacial tension. The practical interpretation of this result would indicate that, although a higher rate of oil production is possible, the ultimate recovery would not be increased appreciably.

The experimental procedure is explained and the results of the tests discussed.

A. J. H.

2431. A study of the mechanism of air-gas drive. D. E. Menzie and R. F. Nielson. *Producers' Monthly*, Mar. 1949, **13** (5), 18.—Although it is appreciated that a higher production is obtained by an increased driving pressure, full agreement has not been reached on the effect of a higher pressure gradient on the ultimate recovery of oil. The purpose of the paper was to investigate that problem.

Tests were carried out on a brine-saturated core, of which it was possible to determine the saturation with the use of a conductivity bridge. To minimize evaporation loss s the driving medium, air, was first saturated by passing it through a brine solution.

The behaviour of each section of the core was investigated and final conclusions listed in the summary. It is stated that the pressure gradient does not appear to effect the ultimate saturation but that the final saturation is a function of the absolute pressure of the section and its relative position on the capillary pressure curve.

Results are expressed graphically. A. J. H.

2432. Deep tests in Ohio. R. L. Alkire. *Producers' Monthly*, June 1949, **13** (8), 26.—The degree of slope of the productive zones from the Cincinnati Arch to the Appalachian geosyncline controls the location of test wells in this region. A short report is given of the wells drilled to the St Peter horizon. The total number of deep tests has been divided in the ratio of 1 : 7 of producers to dry holes, and this fact had discouraged further deep testing.

A structural contour map of the St Peter horizon and a structural map are given. Oil and gas accumulate in local traps, and the existence of suitable structures, therefore, may be representative of productive zones.

The necessity of collecting all available information relating to the search for deep deposits in this area is evident. A. J. H.

2433. Secondary recovery in Clintonville area, southwestern Venango County, Pa. R. W. Harding. *Producers' Monthly*, Jan. 1949, **13** (3), 29.—Deals with some of the present problems encountered in the air drive in the Second and Third Venango Sands, and the water drive in the Second Sand. Originally under dissolved-gas drive, the peak productions were reported to have been 3000–5000 b.d.

Reservoir data, obtained from the Baker coring and electric logging of the air-intake wells, show that the field exhibits no degree of uniformity.

The Second Venango Sand, acquired by the Quaker State Oil Refining Corpn., had been abandoned due to the high water saturation. Information from previously obtained cores confirmed that conditions were suitable for water flooding. The present decline is in the region of 2–3·5% per month.

The common problems of air corrosion and casing leaks were also encountered.

A. J. H.

2434. Secondary recovery of oil in the McDonald field in southwestern Pennsylvania. E. M. Tignor and W. N. Nabors. *Producers' Monthly*, Apr. 1949, **13** (6), 20.—There had been some hesitation in the planning of a secondary project in southwestern Pennsylvania owing to the insufficient supply of natural gas. In 1932, however,

injection of a mixture of 70% natural gas and 30% air was commenced; finally, twelve wells were used for the injection of the gas at pressures ranging between 65 and 100 p.s.i.

The effectiveness of the project may be judged from the fact that, whereas under normal conditions, the field would have reached its economic limit of depletion in 1942 with a cumulative production of 458,716 brl, it is now expected to reach that limit in 1968 with an estimated cumulative production of 643,205 brl.

The relative advantages of different injection programmes have been examined with the aid of electrolytic models.

Extensive data on production and gas-injection rates are tabulated. A. J. H.

2435. Preliminary correlation of the Bradford and Richburg oil sands. R. W. Harding. *Producers' Monthly*, June 1949, **13** (8), 24.—This short survey of the stratigraphy of the Third Bradford and Second Richburg Sands is accompanied by an index map and a sectional map.

The selection of a suitable key horizon presented some difficulties, but it was finally decided to use the Cattaraugus formation, the red shale member being taken as the approx base of the section.

Attempts are made to correlate the characteristics of the two sands. A. J. H.

2436. Novel separation process unlocking Canada's oil sands. W. E. Adkins. *Chem. Engng*, 1950, **57** (5), 103–5.—A complete flow sheet and full details of the quantities, temp, pressure yields, and physical properties are given at all stages of the separation, dehydration, and refining of oil sands in a 500 tons/day experimental plant.

The vast deposits of oil sand of 50–200 mesh contain about 16% oil of sp. gr. 1·004 with the following properties :—

Dist. range	Wt-%	Ultimate analysis,	Wt-%
200° C	1·6	C	83·6
200°–275° C	9·6	H	10·3
Residuum	84·3	S	5·4
Loss	4·5	N	0·4
Asphaltenes	20·2	O	0·2

High-pressure steam and hot water plasticizes the sands, and after screening, the pulp is mixed to coagulate the oil films. Recycling water at 200° F breaks up all lumps, and aeration causes the oil to float in a froth.

Water is settled and flashed off after cutting back with naphtha to 100 Saybolt sec Furol at 122° F. This crude is heated to 825° F under 50 p.s.i. back pressure, and flashed. No coke has been encountered. Capital outlay is $635,000 + $90,000 in office, laboratory, transport, and other facilities. Research is in progress on a cold-water separation system and fluidized-bed operation. D. H.

2437. Patents. L. H. Kaltenberger. U.S.P. 2,506,836, 9.5.50. Describes a device for detonating explosives in oil wells.

C. H. O. Berg and P. H. Jones, assrs to Union Oil Co. of California. U.S.P. 2,506,853, 9.5.50. An oil-well furnace for heating the oil contained in an oil-bearing formation, constituting two concentric tubes located within the well bore extending from the surface to the producing horizon. C. F. S.

Oilfield Development

2438. Exploration in May tops previous records. Anon. *World Oil*, 1.7.50, **131** (1), 79.—734 exploratory wells were completed in the U.S.A. in May 1950, bringing the total for the year to 3147, 7·7% more than in the first five months of 1949. The month's discoveries included 101 new pools, seventy-two new fields, and twenty-nine new pays.

Tables show the results of exploratory drilling in May and first five months, 1950–1949, by districts; and the new oil, distillate, and gas fields and new pay horizons discovered in the U.S.A. in May 1950. C. A. F.

2439. Completions increase sharply in May. Anon. *World Oil*, 1.7.50, **131** (1), 34.—3878 wells were completed in the U.S.A. in May 1950. Total for the year to the end of May was 16,627 wells, 8% higher than for the same period in 1949.

A table shows well completions in the U.S.A. during May 1950, and cumulative for the year, by states and districts. C. A. F.

2440. Oil and gas developments in New York in 1949. W. L. Kreidler. *Petrol. Tech.*, May 1950, **2** (5), 29–30.—In 1949 New York state produced 4,398,000 brl of oil. 875 wells were drilled. There are 23,925 producing wells, all stripper type. The gas production was 3,5000,000 M.c.f.

1949 production statistics are given in tabular form, and a map shows the sites of deep 1949 wells. G. D. H.

2441. Oil and gas developments in Indiana during 1949. R. E. Esarey and B. E. Brooks. *Petrol. Tech.*, May 1950, **2** (5), 1–13.—In 1949 Indiana produced 9,734,000 brl of oil, the bulk being from the Mississippian, followed by the Pennsylvanian and Devonian. During the year twenty-seven new fields, fifteen extensions, and twenty-four new zones were found. 1288 wells were completed (494 field oil wells, 358 field dry holes, 369 dry wildcats, and sixty-six discoveries). The important new fields include Blackhawk and South Terre Haute (Vigo County), Plainville (Davies County), Dead River (Posey County), and Fort Branch (Gibson County).

Intensive efforts are being made to find additional reef structures in the marginal counties of the Basin. Attention is also being paid to areas well up the western flank of the Cincinnati Arch. The Lake of the Woods gas field is in the southern part of the Michigan basin.

Tables list the fields with the name and age of the producing formation, date of discovery, proved oil area, cumulative and 1949 oil production, proved gas area and cumulative and 1949 gas production, total number of wells completed and number completed in 1949, wells producing in December 1949 (flowing and on artificial lift), initial pressure and at the end of 1949, oil gravity, nature, depth, and thickness of producing zone, type of structure, and deepest formation tested. A map shows important 1949 wells. G. D. H.

2442. Oil and gas development in Upper Gulf coast. P. B. Leavenworth and S. A. Parkans. *Petrol. Tech.*, May 1950, **2** (5), 14–28.—The 1949 crude oil and condensate production of the Upper Gulf coast totalled 147,799,338 brl; gas production was 669,729,000 M.c.f. 1306 wells were drilled (692 field oil wells, fifty-five field gas wells, 245 dry field wells, seventy-eight wildcat oil wells, and seventeen wildcat gas wells.) Twelve new oilfields, three gas fields, and thirteen gas and condensate fields were opened. In Block 245 the first production (gas distillate) in open water was obtained from the Miocene at 5934–5968 ft. East Village Mills of Houston County was probably the outstanding discovery.

A map shows the 1949 discoveries, and a table lists the fields with data on oil and gas production, the reservoir rock, oil wells, etc. G. D. H.

2443. The Pennsylvania grade oil industry in 1948. G. G. Bauer. *Producers' Monthly*, Feb. 1949, **13** (4), 40.—It is reported that the production rate was so increased in 1948 as to satisfy the demand for the crude oil. Stocks in hand at the end of that year amounted to 2,439,000 brl.

A decline of 2·8% in the runs to stills, and a slight increase in production were noted in comparison to 1947.

Well completions in 1948, being 5192, showed an increase of 227 over 1947.

The fields of Bradford, Alleghany, West Virginia, Central and South Pennsylvania, and Southeast Ohio are surveyed separately. A. J. H.

2444. Paloma oil field. G. G. Peirce. *Summary Operations Calif. Oilfields*, Jan.–June 1949, **35** (1), 5.—The Paloma field is approx 17 miles southeast of Bakersfield, Kern County, California, and is situated in the San Joaquin basin. Prior to the discovery of oil in 1939, the field produced only gas, and was known as the Buena Vista Lake gas field.

Alluvium conceals underlying structure, and the field was discovered by geophysics, as were several fields in the area. The structure is an elongated dome trending

northwest–southeast. The productive limits extend about 8 miles along the major axis, with a max width of about 2 miles. There is some faulting, which is not believed to be a major factor in the accumulation. Production is from Upper Miocene (Stevens) lenticular sands.

A number of structurally high wells have found water in the pay zone, which is explained by lenticularly and/or permeability barriers. Permeability of pay varies from 50 to 100 mD, and porosity averages 20%.

147 wells had been completed in the field to June 1949, when cumulative oil production was 22,672,068 brl of 30–61° oil.

The history of the discovery of the field and drilling and completion practice are briefly described.

A structure contour map and electric log cross-sections are included. C. A. F.

2445. Central Europe faces petroleum decline. Anon. *World Oil*, 1.7.50, **131** (1), 220.—Current production in Yugoslovia is 1700 b.d., compared with 1040 b.d. in 1949. Daily consumption averages 12,000 b.d. Production is chiefly from Lendava, Gojlo, and the Mramor Brdo fields. Banat and other areas are to be intensively explored.

The Lendava field, discovered in 1942, is on the western extension of the Lovaszi structural trend and separated from the Lovaszi field by a fault. There are three oil pays and one gas pay in the Pliocene at approx 5500 ft.

Gojlo, which originally produced gas, was found to be oil bearing in 1938. There are two oil and one gas pay in the Pliocene at approx 3000 ft.

Mramor Brdo has five wells, one of which is productive.

Oil production in Rumania and Hungary is declining. C. A. F.

Transport and Storage

2446. Pipelines. J. P. A. de Waele. *I. P. Review*, 1950, **4**, 249.—The use of pipes for transporting water dates back to very early times. From the sixteenth century when pumping engines were developed, this use was encouraged, becoming widespread during the last century. The first oil pipeline was one 6 miles long and 4 inches in dia used in Pennsylvania in 1861, but soon afterwards a 2-inch cast-iron pipe equipped with steam-driven pumps was laid for 6 miles also in Pennsylvania. By 1900 18,000 miles of oil pipeline were in use in the U.S.A., and now it is estimated that there are about 170,000 miles there. Economically the use of pipelines is advantageous because, although the initial outlay is heavy, operating costs are low and are mainly fixed charges. Thus a pipeline operating at full capacity may be less expensive than other methods of transport. This has led to the use of larger-dia pipes and indeed pipes with dia of 34–36 inches are now being laid in the Middle East. Constructional developments have been made involving the use of thinner pipes and improved methods of welding which have reduced the cost of production. At the same time, improved pumping methods have led to greater throughput. One of the main difficulties encountered has been the protection of the pipe against corrosion. A special application of the pipeline recently was Operation Pluto, where a series of pipelines was laid across the English Channel for the purpose of transporting petrol. R. H.

2447. Spot reconditioning on pipe line in place, while in service. W. Johnson. *Oil Gas J.*, 10.8.50, **49** (14), 61.—Standard Pacific Gas Line Inc., have "spot" reconditioned a 56-mile length of pipeline, with a crew of twelve men in one area, and a crew of sixteen in another employed over the two-year period.

Excavations averaged 8 ft width and 7 ft depth, pipe was scraped, sandblasted, and cleaned of all scale, before individual pits which had penetrated more than half the thickness of the pipe were welded.

Leaks were repaired with a box-strapping machine using Neoprene rubber plugs over the leaks. After repairs and priming the pipe was given a single wrap consisting of two coats of asphalt approx $\frac{1}{16}$ inch thick, one layer of 40-lb silica-finish pipe covering, and a kraft-paper covering over the second layer of asphalt. The pipe was strip wrapped. Tables show equipment used and cost per foot of pipe. G. A. C.

2448. Launching of the "Velutina." Anon. *Petroleum*, June 1950, **13** (6), 148–9.—An account, with photographs, of the launching ceremony on April 4. Describes very briefly some of the economic considerations that have led to the adoption of super-tankers. R. E. P.

2449. Packaging for the oil industry. D. A. S. Williams. *Chem. Prod.*, Aug. 1950, **13** (9), 355.—Continuing his survey of packaging for the oil industry, the author points out that, although the British Standard Packaging Code is admirable from many aspects, it lacks guidance when a buyer wants to indicate to the supplier the sort of container he requires and also when a buyer wants to choose the best of several alternative packages. It is suggested that this deficiency can be satisfactorily overcome by the publication of a standard text-book, in the compilation of which all interested oil firms should take part.

The advantages of such a course are emphasized by a survey of complaints and reports of losses received over a period of four years.

Article is concluded by a note on the importance of package marking and the derivation of an equation indicating the economic level of packaging. O. M.

2450. Flange, gasket and bolting materials for refinery service. O. L. Lewis. *Oil Gas J.*, 24.8.50, **49** (16), 134.—Factors influencing the choice of flanges, gaskets, and bolts, based on the functions of these accessories, are discussed.

Allowable stress and corrosion resistance have to be considered in choice of flange material. Joint failures have often been due to insufficient bolting and its installation rather than to flanges and gaskets.

Bolts should be uniformly tightened in sequence and equally stressed. Pressures to be encountered should be taken into account when choosing bolts. Gaskets have to create and maintain a tight seal between two separate members of a joint assembly; resist attack from fluids or gases, maintain a satisfactory joint under operating temp conditions, and compensate for minor differences in flange angularity.

Design pressure is important to material selection for all three components, but is more critical to the flange itself.

Four figures illustrate the article. G. A. C.

2451. Evaporation losses are cut over 50% by using new dome-type roof. W. C. Uhl. *Petrol. Process.*, 1950, **5** (6), 619–20.—It is reported that the breathing losses from gasoline storage are reduced from 0·33 to 0·15% of total throughput by the use of a flexible vapour-proof membrane of synthetic-rubber-impregnated nylon, enclosed in a hemisperical "vapour dome" mounted on a standard cone-roof tank. Two installations of this type are described, in one of them the vapour spaces of three existing tanks being connected to the vapour dome of the new tank. D. W. F.

Refinery Operations

Refineries and Auxiliary Refinery Plant

2452. All-welded pressure vessels. A. Flindle. *Mech. World*, 1.9.50, **128** (332), 203.—A method is given of designing vessels having a min surface area for a given internal volume so that economy in material can be effected in the design of dished-end vessels. It may be found that without affecting the internal volume of such a vessel the surface area can be reduced by increasing its dia and shortening its length. The method of dealing with the problem is explained in mathematical detail. A. S.

2453. Ion-exchange. G. Weber. *Oil Gas J.*, 10.8.50, **49** (14), 67.—The use is described of synthetic resin cation and anion exchangers, which give up a hydrogen atom or a hydroxyl group respectively for corresponding charged ions of a compound in solution whereby the ionic particles of the compound originally in solution are in turn adsorbed by the resins and removed from solution. Technique involves numbers of cation- and anion-exchange columns arranged alternately in a series. One application is treating water for laboratory, process, cooling, and boiler feeds. G. A. C.

2454. A small fluidized solids plant for the direct distillation of oil from bituminous sands. W. S. Peterson and P. E. Gishler. *Canad. J. Res.*, 1950, **28F**, 62–70.—The Alberta bituminous sands of northern Alberta cover an area of over 1500 sq. miles. The bitumen content varies generally from a few per cent to 17% by weight, and the bed thickness from a few feet to 2000 ft. In one of the richest areas studied a bitumen content of 200 million brl per sq. mile has been estimated.

The results of a laboratory-scale investigation (see Abstract No. 913) have been used to design the pilot plant described. The sand is fed directly into a hot fluidized bed, and 80% by vol of the bitumen is recovered. The bulk of the product is a heavy oil of sp. gr. *ca* 0·95, 4·0% sulphur, and I.B.P. *ca* 400° F. About 3% of the total oil was recovered as a light distillate of sp. gr. 0·746 and I.B.P. 128° F. D. F. J.

2455. Aluminium welding by the Argon Metal Arc. Anon. *Refiner*, 1950, **29** (6), 134.—A brief outline of a welder suitable for aluminium alloys. The electrode is supplied as a coil of aluminium wire which is deposited as filler. Aluminium, ranging in thickess from $\frac{1}{4}$ to $1\frac{1}{2}$ inches, has been welded. The process easily welds butt, fillet, and lap joints. R. W. G.

2456. The new metals—molybdenum, titanium and zirconium. Anon. *Refiner*, 1950, **29** (5), 138.—Molybdenum and titanium are now obtainable in limited quantities. Molybdenum has superior strength (compared with present-day metals); above 1900° F it also shows outstanding resistance to hydrochloric acid. However, it shows severe oxidation at red heat and is difficult to weld. Titanium is abundantly plentiful, is only 67% heavier than aluminium, has a tensile strength of 150,000 p.s.i., and excellent corrosion resistance. Zirconium is only in early stages of development, but is superior in corrosion-resistance to titanium and the stainless steels.

A table is presented showing the mechanical properties of these three metals as compared with those of common metals. R. W. G.

2457. Air cooled heat exchangers. Economics of use in refineries. K. D. Demarest. *Petrol. Process.*, 1950, **5** (6), 633–4.—Arguments in favour and economics of use of air-cooled heat-exchangers using fans are given. D. W. F.

2458. Design of cathodic protection for open-box type coolers. C. R. Draughton and E. B. McNeil. *Petrol. Process.*, 1950, **5** (6), 629–32.—(*Corrosion Session, A.P.I., Refining Division, Cleveland, May* 2.)—Details of anode distribution and operating conditions are given for the cathodic protection of a large open-box cooler at the Baton Rouge refinery of Esso Standard Oil Co. Large anode areas and relatively close spacing are necessary for good current distribution. Steel-plate anodes, $10\frac{1}{2}$ ft long by 1 ft wide spaced 30 inches centre to centre in line between tube banks, with a 50 mA per sq. ft. anode-surface current density were used in the first installation, but C steel cylindrical anodes spaced 16 inches apart were found to give better current distribution in a later installation. Plate anodes gave protection to 65% of the box and coil surface with a protected surface current density of 5·3 mA per sq. ft. Pit penetration of 0·02–0·05 inches per year was observed on the area attacked, as against 0·15 inches per year prior to protection. Average cost of protection is given as 66 cents/sq. ft. of surface protected. D. W. F.

2459. Process gives plant water free of scale and corrosion. J. C. Albright. *Refiner*, 1950, **29** (7), 119–22.—A description of a water-plant treating 200-ft well water for refinery plant. The process consists of a coke aerator to oxidize and precipitate iron and manganese followed by zeolite treating. The treated water has proved to be very clean. R. W. G.

2460. Scrubbing devices successfully control air pollution from refinery processes. E. P. Kropp. *Petrol. Process.*, 1950, **5** (6), 627–9.—(*A.P.I. Refining Division* 4, *Cleveland, May* 3.)—Air pollution from Standard Oil refinery in Cleveland has been greatly reduced by installation of commercial scrubbing units known as fog filters. These consist of two cylindrical spray chambers connected by a cross-over duct. Fumes pass down central inlet pipe to near base of first chamber, up through fog sprays, over into next chamber, down through more sprays, and away up the central outlet

pipe. Main pollution is associated with SO_2 from lube oil acid treating, fatty acid odour, and H_2S from grease-making and asphalt manufacture. The filter has been successfully applied to the removal of SO_2 and H_2S from process fumes, reduction from 10,000 to 1 p.p.m. SO_2 being achieved in the test. D. W. F.

2461. Patent. F. E. Frey, assr to Phillips Petroleum Co. U.S.P. 2,507,778, 16.5.50. A pressure vessel comprising in combination an inner shell to receive fluids under superatmospheric pressure, an outer corrugated expanding shell, with overlapping plates around it, liquid filling the space in between the shells, a helical winding of a synthetic organic fibre around the plates, and a suitable coating material to protect the fibre from air and moisture. C. F. S.

Distillation

2462. Wartime toluene plant converted to 50,000 b.d. topping unit. W. L. Bass and V. E. Smith. *Petrol. Process.*, 1950, **5** (6), 615–18.—The engineering and construction problems arising from the conversion of a wartime plant for the extraction of toluene by methanol azeotropic distillation into a twin 50,000-b.d. total crude topping plant, to supply feed stock for a Houdry cracker are reported. The two azeotropic towers were adapted as fractionaters by the removal of the reduced-dia top section, relocation of trays to provide a stripping section, and incorporation of draw-off pots for side streams. Two gas-fuel oil heaters, heat exchangers, pumps, instruments, and fittings were also utilized, resulting in a substantial cost saving being achieved in comparison with a new installation. D. W. F.

2463. Furfural–water system. Experimental and theoretical vapour–liquid relationships. E. J. Pearce and J. A. Gerster. *Industr. Engng Chem.*, 1950, **42** (7), 1418–24.—Vapour–liquid equilibrium data were obtained for furfural–water system at 100°, 150°, and 250° F by the b.p. method (determination of pressure at which liquid of known composition begins to boil). Activity coeff and partial heats of solution were calc from the data for each component of the system. Few of the many equations which may be used to represent activity coeffs as functions of composition were valid for this system. To apply the data to complex mixtures with furfural and water, separate three-suffix Margules equations are required to apply to separate concentration ranges, with special constants for that range. The procedure is claimed to be thermodynamically sound, and allows use of simple Margules-type equations, which are desirable for representing more complex systems. R. G. T.

2464. Calculation methods for equipment for the distillation, absorption and extraction of multicomponent mixtures. A. H. de Haas van Dorsser. *Ingenieur*, 25.8.50, **62** (34), Ch 59.—Article opens with reference to the development of processes which required methods for the calculation of the min number of stages necessary to obtain the required separation of components, and mentions the particular industries which fostered the further research into theoretical methods.

The methods derived by a number of workers are mentioned and their shortcomings indicated, but pride of place in the paper is given to Van Wijk (whose work occupies more than half of it), who uses an absorption factor in his calculations. Several equations are given by way of illustration of this method, which, the author maintains, is one of great practical importance to Netherlands industry. R. R.

2465. Fractionator calibration system—binary vs. multicomponent test mixtures. C. B. Kincannon and E. Manning, Jr. *Industr. Engng Chem.*, 1950, **42** (7), 1386–8.—A thirty-plate 1-inch i.d. Oldershaw glass distillation column was used to investigate the effect of number of components present in the calibration system used in the calculation of plate efficiency. Systems used were of saturated paraffins with same number of C atoms/mol. Conditions were same in all tests, calculations were comparable and based on v.p. from one source. Mass spectrometer analyses were made and plate eff calc for multicomponent and binary mixtures. Number of theoretical plates remained constant (fifteen plates) for systems having two to six components. Authors thus conclude eff of laboratory columns is not affected by number of components in the feed. R. G. T.

2466. Patents. M. W. Davidson, assr to Phillips Petroleum Co. U.S.P. 2,506,858, 9.5.50. Azeotropic distillation of a mixture containing hydrocarbons of at least two of the series paraffins, naphthenes, and aromatics, in the presence of tetrahydrofuran.

J. W. Throckmorton and J. S. Wallis, assrs to Petro-Chem Process Co. Inc. U.S.P. 2,507,325, 9.5.50. Bubble-tower construction and method of fractionating vapours. C. F. S.

Absorption and Adsorption

2467. Adsorption equilibria—hydrocarbon gas mixtures. W. K. Lewis, E. R. Gilliland, B. Chertow, and W. P. Cadogan. *Industr. Engng Chem.*, 1950, **42** (7), 1319–26. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—A study of the vapour-adsorbate equilibria for binary mixtures of lower gaseous hydrocarbons on silica gel and several activated carbons has been made. Pressures from <1 to 20 atm, and temp from 0° to 40° C were used. The amount of gas adsorbed was, in all cases, less in the mixture than it would have been if the other component had not been present. Adsorption correlations are made to predict adsorption equilibria. Authors conclude that preferential adsorption depends on mol. wt., structure, b.p. Adsorption on SiO_2 gel is more dependent on structure than adsorption on activated carbon. C adsorbs higher-mol.-wt. gases. R. G. T.

2468. Adsorption equilibria—pure gas isotherms. W. K. Lewis, E. R. Gilliland, B. Chertow, and W. P. Cadogan. *Industr. Engng Chem.*, 1950, **42** (7), 1326–32. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J.*, Sept. 1949.)—Adsorption equilibria were measured for eight lower hydrocarbons from C_1 to C_4 on SiO_2 gel and several activated carbons. Most of the data were obtained at 25° C and up to 1 atm. Some cases were studied to 250° C and 20 atm. Correlation of the adsorption isotherms is made by modification of Polanyi adsorption potential theory and is reasonable except for methane or SiO_2 gel. For carbon, low v.p. is predominant factor favouring adsorption, unsaturation in the gas mol playing a lesser part unless volatilities are close on SiO_2 gel. Unsaturation in the mol has significant influence on adsorption capacity of the carbons and SiO_2 gels for the gases differ widely. R. G. T.

2469. Adsorption of gases on activated charcoal. G. C. Ray and E. O. Box, Jr. *Industr. Engng Chem.*, 1950, **42** (7), 1315–18. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Equilibrium adsorption data are presented for hydrogen, nitrogen, carbon monoxide, carbon dioxide, methane, acetylene, ethylene, ethane, propylene, propane, and *n*-butane on one sample of coconut charcoal. Pressures from 0 to 215 p.s.i. and temp from 100° to 450° F are used. Adsorption isotherms for methane, ethane, propane, and ethylene are drawn and compared. R. G. T.

2470. Alumina surface area measurements—by nitrogen, *n*-butane, propane, and stearic acid sorption. A. S. Russell and C. N. Cochran. *Industr. Engng Chem.*, 1950, **42** (7), 1332–5. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Surface areas of aluminas of various pore widths, crystal structures, and surface compositions have been compared by the B.E.T. (Brunauer, Emmett, and Teller) method for *n*-butane and nitrogen sorption : Samples studied were heated α-alumina trihydrates, heated alumina gels, molybdena-impregnated alumina dehydrocyclization cats, SiO_2–Al_2O_3 cracking cats, and SiO_2–aluminas with deposited coke from cat cracking. A remarkably consistent correlation was found between *n*-butane and nitrogen sorption for all samples. *n*-Butane and propane show the same number of mols in the B.E.T. monolayer. Sorption of stearic acid is used to measure surface areas of finely divided non-porous aluminas. R. G. T.

2471. Surface areas of heated alumina hydrates. A. S. Russell and C. N. Cochran. *Industr. Engng Chem.*, 1950, **42** (7), 1336–40. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Materials of high surface area have been produced by calcination of the four alumina hydrates. Several hydrates

of high surface area are also discussed. Influence of temp, atmosphere, and duration of heating on surface areas of various forms of α-alumina monohydrate, α-trihydrate, and β-alumina monohydrate and trihydrate are reported. Trihydrates produced the greatest surface area, but the most heat-stable area was shown by the α-monohydrate. Amorphous aluminas did not necessarily have greater surface areas than crystalline forms. Activation processes are discussed for aluminas of a wide range of surface areas and crystal structures. R. G. T.

2472. Separation of iso- and normal paraffins by adsorption. H. J. Hibshman. *Industr. Engng Chem.*, 1950, **42** (7), 1310–14. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Various adsorbents have been used to separate straight-chain and branched-chain paraffins. Authors here report on separation of pentane, hexane, and heptane from *iso*-octane using activated carbon. Analogy between this separation and extraction or distillation is supported by the beneficial result of countercurrent operation. Regeneration of the adsorbent by heating at 900° F, steaming at 580° F, and washing with hydrocarbons, is described. The latter has the advantage that certain wash solvents do not impair the selectivity of the carbon and therefore need not be washed off before re-use. Small flow chart is included and described. R. G. T.

2473. Separation and desulphurization of cracked naphtha—application of cyclic adsorption process. S. Eagle and C. E. Rudy, Jr. *Industr. Engng Chem.*, 1950, **42** (7), 1294–9. (*Adsorption Symposium. 116th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Hydrodesulphurization of thermally cracked naphtha without excessive loss in O.N. is made possible by the method herein described. Pentane is used (in a cyclic adsorption plant) to remove a high-sulphur aromatic extract and leave a paraffin-naphthene–olefin raffinate. The extract is hydrodesulphurized and blended with the raffinate producing a valuable low-sulphur gasoline blend. An eight-column cyclic-adsorption pilot plant is described. Plant data for this plant and for hydrodesulphurization unit are presented. O.N. studies of the raffinate extract, of blends of the two, and of other blends of the raffinate with straight-run gasoline were made and results compared with typical gasolines. R. G. T.

2474. An elementary theory of adsorption in fluidized beds—mathematics of adsorption in beds. P. R. Kasten and N. R. Amundson. *Industr. Engng Chem.*, 1950, **42** (7), 1341–6.—Adsorption in a fluidized bed is discussed assuming uniform porous spheres for adsorbent. They are assumed to move at random in a bed with supporting fluid of uniform concn. If equilibrium is reached in the spheres, adsorbate concn of the fluid and solid are related according to the system isotherm, here assumed linear. If rate of adsorption is too slow for equilibrium a linear reversible kinetic relation is applied. A resistance to main transfer at the interface is postulated. Theory applies only to special cases on dilute solutions, but qualitative conclusions may be drawn for other cases, and results should be applicable to more important processes of cat. R. G. T.

2475. Petroleum hydrocarbons—separation and analysis by adsorption. B. J. Mair. *Industr. Engng Chem.*, 1950, **42** (7), 1355–60.—Work of A.P.I. Research Project 6 in development of fractional adsorption for separation and analysis of hydrocarbons is reviewed. Methods of operation and apparatus and materials are described. The theory underlying the process is shown, with equations for computation of separation factor and height equivalent of unit theoretical stage of separation. Experimental figures for these latter two are reported, and application of the process to separation, analysis, and purification of hydrocarbons of varying type and mol.-wt. range is described. R. G. T.

Solvent Extraction and Dewaxing

2476. Fractional solvent extraction with reflux. G. F. Asselin and E. W. Comings. *Industr. Engng Chem.*, 1950, **42** (6), 1198–205.—The fractionation obtainable in the separation of a mixture of two components by countercurrent extraction with two immiscible solvents and the return of reflux has been investigated. A five-stage

countercurrent extractor was used to determine the effects of varying solvent ratio, the total concn of the two components in the feed, and the feed composition on a solvent-free basis. A stagewise graphical method of calculation is presented permitting the computation of the effects of the extraction when using reflux return. Seventeen references. D. W. F.

2477. Mechanism of solute transfer in spray towers. W. Licht and J. B. Conway. *Industr. Engng Chem.*, 1950, **42** (6), 1151–7.—From a fundamental study of spray tower operation, three separate stages of extraction have been proposed and their existence verified using the extraction of acetic acid from single drops of water by a stationary column of *iso*propyl ether, methyl *iso*propyl ketone, and ethyl acetate. The extraction stages are drop formation, passage of the drop through the column, and finally coalescence at the solvent–water interface. The percentage extraction for each stage has been evaluated, and some of the factors affecting each stage are discussed. Nine references. D. W. F.

2478. Limiting flow phenomena in packed liquid–liquid extraction columns. J. H. Ballard and E. L. Piret. *Industr. Engng Chem.*, 1950, **42** (6), 1088–98.—Employing a 3·75-inch internal dia glass column packed with $\frac{1}{2}$-inch porcelain Raschig rings, the flow mechanism of countercurrent liquid–liquid extraction in packed columns has been studied. Three distinct modes of flow behaviour occurring as the dispersed solvent rate is increased are discussed, called by the authors flooding, phase reversal, and slugging. Prior to reaching one of these states, the column passes through a stage when drop enlargement becomes apparent, defined as the "transition point." The following correlation for the transition points was achieved, which though agreeing with previously published data on flooding of gas–liquid adsorption columns does not correlate previous flooding data for liquid–liquid columns. Good literature review and bibliography.

$$0{\cdot}55 \cdot \frac{g^{0{\cdot}275}\,\Delta\rho^{0{\cdot}465}}{u_w^{0{\cdot}5}\,\rho_w^{0{\cdot}415}\,\mu_w^{0{\cdot}05}} \left(\frac{F}{a^{0{\cdot}65}}\right)^{0{\cdot}5} \left(\frac{\sigma_{ws}+\sigma_{sa}}{\sigma_{ws}}\right)^{0{\cdot}2} = 1{\cdot}70 \left(\frac{u_s}{u_w}\right)^{0{\cdot}5} \left(\frac{\rho_s}{\rho_w}\right)^{0{\cdot}3} + 1.$$

u = superficial fluid volocity based on empty column ft/hr.
ρ = density lb/cu. ft.
$\Delta\rho$ = phase density difference lb/cu. ft.
μ = viscosity lb/ft hr.
a = surface area factor for packing ft^{-1}
F = packing fractional free volume.
σ = interfacial or surface tension.
g = gravitational constant ft/hr^2.

Subscripts

w = water or fluid preferentially wetting the packing.
s = solvent or fluid not preferentially wetting the packing.
a = air.

D. W. F.

2479. Patent. R. E. Manley, assr to The Texas Co. U.S.P. 2,507,861, 16.5.50. A method of producing diesel fuel oil from a residual crude by heating to a temp of 800°–850° F, so that the feed undergoes thermal cracking, then distilling from the thermally cracked crude a gas-oil fraction, then subjecting this fraction in vapour phase to contact with a fluidized alumina–silica cracking catalyst to convert about 50% into gasoline and lower-boiling material, fractionating from the cat-cracked products a second gas-oil fraction, and subjecting this to solvent extraction with furfural saturated with water. C. F. S.

Cracking

2480. New Houdriflow cracking unit has high catalyst–oil ratio, low preheat requirements. D. P. Thornton. *Petrol. Process.*, 1950, **5** (6), 601–5.—The entire operating scheme of the second Houdriflow catalytic cracking unit, now approaching completion at the Drumright, Okla. refinery of Tide Water Associated Oil Co., is briefly reviewed.

The main difference between the Houdriflow and the conventional T.C.C. process, of which it is a modification, is that the air-lift principle is utilized to lift the regenerated catalyst to the top of the unit by means of a portion of the regeneration flue gas. A much higher catalyst-to-oil ratio of 8 : 1 (max) is possible which leads to a reduction in feed preheat requirements. Design capacity is 4500 b.d. of a vacuum gas oil from a sweet Mid Continent crude, with up to 50% recycle oil. 96% yield on charge is claimed, of which 50% is a 79–80 Motor octane clear-cracked gasoline. D. W. F.

2481. T.C.C. liquid-feed operations. G. Weber. *Oil Gas J.*, 31.8.50, **49** (17), 54.—A two-week test run on the T.C.C. unit at the Casper, Wyo, refinery of the Socony-Vacuum Oil Co. is reported; the data given are representative of overall refinery operations during the past year.

The unit is of conventional post-war type with the exception of the reactor design providing liquid feed; and the operation of the feed-preparation section,

Tables give ultimate T.C.C. yields, component yields, charge-stock and product inspections, and operating conditions.

A flow sheet of the unit is also provided. G. A. C.

2482. Patents. J. Hoekstra, assr to Universal Oil Products Co. U.S.P. 2,506,923, 9.5.50. Cracking of hydrocarbons with silica–alumina catalyst treated with hydrogen fluoride in an amount not greater than 20% by weight of the catalyst.

H. L. Pelzer, assr to Sinclair Refining Co. U.S.P. 2,507,220, 9.5.50. A method of cracking heavier, higher-boiling hydrocarbons to produce lighter, lower-boiling hydrocarbons, with an anhydrous ammonium fluoride catalyst.

E. J. Houdry, assr to Houdry Process Corpn. U.S.P. 2,507,523, 16.5.50. Conversion of heavy hydrocarbons containing tarry or asphaltic material to volatile hydrocarbons and coke.

E. B. Miller. U.S.P. 2,507,538, 16.5.50. An improved method and apparatus for catalytic cracking of hydrocarbons, which comprises rotating a series of separated thin beds of catalyst through a reaction and regeneration zone; continuously directing the flow of vaporized hydrocarbons through reaction zone; heating hydrocarbons prior to their passage through reaction zone; continuously withdrawing the cracked hydrocarbons from the reaction zone; continuously directing the flow of a hot oxidizing medium through the regeneration zone to burn the residual gas in the beds and also to oxidize the carbon on the catalyst; and continuously withdrawing the resulting carbonaceous gases from the regenerating zone.

C. H. Earhardt, assr to Universal Oil Products Co. U.S.P. 2,507,625, 16.5.50. A catalyst for the conversion of hydrocarbons prepared by calcining a silica-gel magnesia composite impregnated with an ammonium phosphate solution. C. F. S.

Hydrogenation

2483. Residual oil hydrogenation. L. C. Skinner, E. E. Donath, E. Schappert, and E. Frese. *Refiner*, 1950, **29** (7), 83–7.—A hydrogenation process suitable for converting cracked and straight-run residual oils into high-quality distillates: diesel fuel, kerosine, jet fuel, gasoline, etc. Liquid- and vapour-phase hydrogenation stalls are used in series, heat-exchanger equipment is extensively employed. Hydrogen is supplied by a hydrocarbon–steam cracking unit, and pelleted tungsten and nickel sulphide on alumina is used as vapour-phase catalyst to reduce sulphur, nitrogen, and oxygen compounds, saturate and split high-mol.-wt. hydrocarbons. With an operating pressure of 10,000 p.s.i. and temp of 900° F cracked residues, regardless of type and origin, can be hydrogenated with high throughput and yield, sulphur, nitrogen, and oxygen compounds being eliminated. At lower pressures, cracked residues would yield aromatic distillates leading to low-grade diesel fuel and/or catalytic cracking stock. Capital and operating costs are discussed, and the process is considered economical for some areas. Allowing a fifteen-year amortization period, the total processing costs are 3·36 cents (U.S.) per gal feed (cracked residue). R. W. G.

2484. High-pressure hydrogenation of carbonaceous matter. Part VII. P. W. Sherwood. *Refiner*, 1950, **29** (7), 124–8.—Vapour-phase hydrogenation of petroleum stocks at 10,300 p.s.i. is discussed and compared with hydrogenation at 4400 p.s.i. The higher pressure enables the production of higher aromatic and knock-resistant gasolines. The Ruhröl catalyst, composed of molybdenum, chromium, zinc, and sulphur on a fuller's earth base, is favoured over the normal 10% tungsten sulphide on fuller's earth, as being impervious to the presence of nitrogen and oxygen compounds. Gasolines produced by high-pressure hydrogenation are highly stable, susceptible to lead, of good colour, and non-corrosive. Properties of gasolines produced from several types of feed are reported (including bituminous coal products). R. W. G.

Polymerization

2485. Patents. W. W. Crouch, assr to Phillips Petroleum Co. U.S.P. 2,506,857, 9.5.50. A process for the polymerization of a conjugated diolefin in the presence of a finely-divided alkali-metal catalyst in admixture with 50 to 400 parts by weight of a low-boiling inert diluent per 100 parts of diolefin, and 0·5–10 parts by weight of a surface-active agent per 100 parts of diolefin.

F. A. Howard and A. D. Green, assrs to Standard Oil Development Co. U.S.P. 2,507,105, 9.5.50. A process for the Friedel–Crafts catalysed low-temperature polymerization of *iso*olefins.

D. W. Young and H. D. Hineline, assrs to Standard Oil Development Co. U.S.P. 2,507,133, 9.5.50. Nitrite ester diluent polymerization process where vinyl *iso*butyl ether and a nitrite ester as a diluent are mixed at a temp between 10° and −164° C and polymerizing by the application of a Friedel–Crafts catalyst in solution in the diluent.

R. G. Heiligmann, assr to Atlantic Refining Co. U.S.P. 2,507,338, 9.5.50. The polymerization of α-alkyl styrenes by contacting a solution of α-alkyl styrene in 6–25 vols of a liquefied normal mono-olefin with 0·25–5% of a Friedel–Crafts catalyst.

F. J. Moore and M. M. Stewart, assrs to The Texas Co. U.S.P. 2,507,864, 16.5.50. Catalytic polymerization of C_3 olefins using a solid granular catalyst comprising a synthetic gel of the acid-treated zeolite type with the composition $Al_2O_3 \cdot 5SiO_2$. C. F. S.

Alkylation

2486. Patents. P. H. Carnell, assr to Phillips Petroleum Co. U.S.P. 2,507,764, 16.5.50. A process for the conversion of an acid-soluble oil obtained from the acid phase of a process for the alkylation of an *iso*paraffin with an olefin, by primarily alkylating an *iso*paraffin with the acid-soluble oil in presence of hydrofluoric acid as the catalyst and absence of low-boiling olefins, and producing gasoline and lubricating-oil fractions.

F. M. Smith, assr to Phillips Petroleum Co. U.S.P. 2,507,765, 16.5.50. A two-step process for catalytically producing high-mol.-wt. alkyl benzenes by mixing alkylatable benzene hydrocarbons and olefin-bearing material with a liquid-type alkylation catalyst.

F. M. Smith and R. S. Hanmer, assrs to Phillips Petroleum Co. U.S.P. 2,507,766, 16.5.50. An improved process for catalytically producing high-mol.-wt. alkyl benzenes by mixing alkylatable benzene hydrocarbons and olefin-bearing materials with hydrogen fluoride. C. F. S.

Chemical and Physical Refining

2487. Liquid-phase hydrogen sulphide removal. L. W. Zahnstecher. *Refiner*, 1950, **29** (7), 107–10.—A description of a regenerative H_2S-removal plant for a propane–propylene and butane–butylene feed to a catalytic polymerization plant for gasoline production. Tri-potassium phosphate is used in an extractor packed with Raschig rings, and is regenerated by heating to about 235° F. Advantages include preferential absorption of H_2S over CO_2, non-volatility, insolubility in hydrocarbon feed, ease of handling, non-poisonous, non-corrosiveness, and non-inflammability. R. W. G.

2488. Crystalline adducts of urea with linear aliphatic compounds—a new separation process. W. J. Zimmerschied, R. A. Dinerstein, A. W. Weitkamp, and R. F. Marschner. *Industr. Engng Chem.*, 1950, **42** (7), 1300–6 (116*th Mtng Amer. Chem. Soc., Atlantic City, N.J., Sept.* 1949.)—Urea forms crystalline complexes with *n*-alkanes and their derivatives, but not with most branched and cyclic hydrocarbons and their derivatives. Stability of the complexes enables separation of *n*-alkanes from branched and cyclic compounds. The adducts are readily formed at room temp, are stable at that temp, and their components can be almost quantitatively recovered by action of water. Heat of formation is smaller than heat of adsorption of the hydrocarbons upon solid surfaces, and authors postulate that the hydrocarbon chains penetrate the urea molecule, and thus separation by means of such adducts depends on molecular structure. In combination with distillation and adsorption, the technique here described should show wide application. R. G. T.

Special Processes

2489. *Iso*synthesis process. Anon. *Oil Gas J.*, 17.8.50, **49** (15), 92.—This article is a summary of a German paper entitled "High pressure hydrogenation of carbon monoxide to predominantly *iso*paraffinic hydrocarbon (*Iso*synthesis)" published in *Brenstoff-Chemie*, 13.1.49, p. 13.

The behaviour of single and multiple catalysts in the reaction of carbon monoxide and hydrogen under pressure to form hydrocarbons are tabulated. It is shown that the best single catalyst is thorium oxide. A mixture of zinc and thorium oxides gave an increased yield of liquid hydrocarbons, and the addition of aluminium oxide increased the yield of *iso*butane. G. A. C.

2490. Patents. H. H. Jones, assr to Phillips Petroleum Co. U.S.P. 2,506,720, 9.5.50. The process of hydrocarbon conversion with Friedel–Crafts type metal halide catalysts, and the improvement by initiating flow of vapours at conversion conditions over freshly reactivated catalyst at a lower flow-rate than is optimum for the greater part of the conversion period, continuing low flow rate until conversion increases to min value, and then increasing flow rate to optimum for the balance of the conversion period.

J. Winston and F. L. Weinstein, assrs to Standard Oil Development Co. U.S.P. 2,507,131, 9.5.50. Method of incorporating gas into clay slurries comprising adding a small amount of an ester of tripolyphosphoric acid in which one hydrogen atom is replaced by an alkali metal and the remainder reacted with an esterifying alcohol ROH, where R is an aliphatic hydrocarbon radical having up to eight carbon atoms, and agitating the mixture violently with the gas to be incorporated.

W. G. Frankenburg, assr to Hydrocarbon Research, Inc. U.S.P. 2,507,510, 16.5.50. Process for producing normally liquid hydrocarbons boiling in the gasoline range, by passing a mixture of CO and H_2 into a reaction zone and contacting with a titanium boride catalyst.

L. W. Mixon and E. N. Roberts, assrs to Standard Oil Co., Indiana. U.S.P. 2,507,731, 16.5.50. An improvement in the process of reacting phosphorus sulphide and olefinic hydrocarbon, which comprises carrying out the reaction in the presence of from about 5% to about 100% by weight, based on the olefinic hydrocarbon, of an aromatic hydrocarbon. C. F. S.

Metering and Control

2491. Instrumentation of process equipment and tankage. Anon. *Oil Gas J.*, 31.8.50, **49** (17), 66.—The Barnsdall Oil Co. have installed a greater number of liquid-level controls and recording instruments than usual in order to protect the investment and to offer a high degree of safety for the operatives.

Operation of all safety and emergency equipment is checked periodically, and the automatic instruments have never had to function except for these tests. G. A. C.

2492. Automatic process systems require careful selection of control valves. J. Procopi. *Petrol. Process.*, 1950, **5** (6), 621–4.—Design and construction features of

the spring-opposed and springless diaphragm motor-operated type of control valve are discussed. Reasons for adoption of the double port valves are given, together with the valve characteristics of the quick opening, linear, and equal-percentage-type plugs. Materials of construction for different conditions and equations for using the " flow coefficient " method of valve-size selection are presented. D. W. F.

PRODUCTS

Chemistry and Physics

2493. Atomization of liquids by means of a rotating cup. J. O. Hinze and H. Milborn. *J. appl. Mech.*, 1950, **17** (2), 145–53.—The investigation reported is concerned with the development of a rotating-cup atomizer for application in a burner for small capacities (1 g.p.h.). The liquid is supplied through a stationary tube to the inner surface of a rotating cup widening towards a brim, and is then flung off by centrifugal action. The flow in the cup and the following disintegrating process is investigated theoretically and experimentally. Three types of disintegration may take place : (1) direct drop formation, (2) ligament formation, (3) film formation. Transitions in the direction (1)–(2)–(3) are promoted by increased quantity of supply, increased angular speed, decreased dia of cup, increased density, increased viscosity, and decreased surface tension. The experimental results are expressed in terms of relevant dimensionless groups. Results of drop-size measurements for the states of ligament formation and film formation show that rotating-cup atomization is much more uniform than that usually achieved by pressure atomization. D. F. J.

2494. The dielectric constant. A. V. Brancker. *Petroleum*, Aug. 1950, **13** (8), 194–6.—The dielectric constants of transformer oils are determined as a routine procedure. The fundamental significance of the constant is explained, and its physical relationship with refractive index and polarizability shown. Methods are briefly outlined for its determination for solids and liquids.

It is shown that silicone liquids exhibit dielectric properties which are characteristic of such solid materials as fused silica, polythene, polystyrene, and liquids such as transformer oils. A silicone of visc 0·65 cs has properties very similar to transformer oils. R. E. P.

2495. Transition in high polymeric materials. R. Buchdahl and L. E. Nielson. *J. appl. Phys.*, 1950, **21**, 482–7.—The views for and against the " second order " transition in polymers in terms of a thermodynamic transition of second order are reviewed. Experimental results are given which show that the existence of a thermodynamic transition of second order is in accord with the experimental findings and does not invalidate the existence of dispersion effect. The relaxation theory is insufficient to explain transitions observed by mechanical, electrical, and thermal measurements. The three objections against the assumption of a thermodynamic transition are shown to be invalid. Owing to lack of data it was found impossible to ascribe conclusively the thermodynamic transition to a specific molecular process, but evidence is provided which shows that the " hindered " rotation explanation is most likely. N. T.

2496. Behaviour of granulated polymers under pressure. R. S. Spencer, G. D. Gilmore, and R. M. Wiley. *J. appl. Phys.*, 1950, **21**, 527–31.—Frictional forces between a polymer and channel walls in extrusion or injection moulding lead to a pressure drop through the granular material ; at the same time applied pressure leads to compaction of the granules.

A simple theoretical expression for pressure transmission can be derived assuming that the granular mass has certain fluid-like properties ; good agreement being obtained between theory and experiment in the case of seran powders and granular polystyrenes. The effect of lubrication is shown.

The compaction of the polystyrenes follows the same order as that observed in the earth's crust. The porosity decreases exponentially with increasing pressure, and the " compression coefficient " for the porosity of granular polystyrene is comparable with that given for clays and shales. N. T.

2497. Emulsion polymerization with ultrasonic vibration. A. S. Ostrospi and R. B. Stanibough. *J. appl. Phys.*, 1950, **21**, 478–82.—A magnetostriction-type oscillator operating at 15 kc was found to eliminate the induction period in an emulsion-type polymerization of styrene. At 50° C the ultrasonic irradiated reaction did not differ markedly from the control, but at 40° C the difference was pronounced. Using a piezo-electric oscillator at 500 kc, the results were comparable with the magneto-striction oscillator. Experiments were made to separate local heating effects from those due to vibrational energy. Polymerization of butadiene under pressure of up to 60 p.s.i. required $\frac{1}{2}$ watt vibrational power/cc of latex to double the yield in a given reaction time, which is much greater than that required for polystyrene. Essentially the same results were obtained for GR.S. Redox, and Redosol formulæ. The ultra-sonic intensity apparently must exceed a critical value before any appreciable accelera-tive effect can be observed, and after this value the time to reach a given yield of polymer is approximately inversely proportional to the power used. N. T.

2498. Mechanical properties of substances of high molecular weight. VIII. Dispersion of dynamic rigidity and viscosity in concentrated polyvinyl acetate solutions. J. D. Ferry, M. W. Sawyl, V. Browning, and A. H. Groth, Jr. *J. appl. Phys.*, 1950, **21**, 513–17.—Using transducer and wave-propagation methods the dynamic rigidities and visc of conc solutions of polyvinyl acetate in 1 : 2 : 3-trichloropropane have been obtained. Number average M.W. of 140,000 and 840,000 of two polymer samples were studied in the lower audio-frequency range at concn of 5–40% and temp of −3° to 41° C. For each sample the reduced dynamic rigidity and reduced dynamic visc were plotted against the reduced radio frequency, all the data superposed to give two composite dispersion functions. N. T.

2499. Thermochemistry for the petroleum industry. Part XII—Oxides of nitrogen. K. A. Kobe and R. E. Pennington. *Refiner*, 1950, **29** (7), 129–33.—The paper presents data on the heat capacities, mean heat capacities, heat-capacity equations, enthalpies, free energies of formation, heats of formation, and mol. wt. of N_2, NO, N_2O, NO_2, and N_2O_4, and dissociation curves are given for NO_2 and N_2O_4. R. W. G.

2500. Solubilization and cosolvent effects with sodium stearate. R. C. Merrill. *J. Phys. & Colloid Chem.*, 1950, **54**, 482–8.—Solution temp of various concn of sodium stearate are decreased by potassium stearate, to a greater extent by sodium laurate, and also by six modern detergents. Cresol, *cyclo*hexane, and *cyclo*hexamine also decrease the solution temps of sodium stearate, whereas other organic additives have variable effects. (Author's summary.) D. F. J.

2501. A new activity relationship for binary solutions of nonelectrolytes. A. E. Martell. *J. Phys. & Colloid Chem.*, 1950, **54**, 459–66.—A simple relationship is derived between activity and mol fraction for binary solutions showing small positive deviations from Raoult's law. The constancy of the single parameter of the equation is shown at const temp over the whole range of composition. Vapour pressures predicted are compared with experimental values for a number of binary systems. D. F. J.

Analysis and Testing

2502. Suspending power of detergent solutions.—I. Pure Soaps. A. S. Weatherburn, G. R. F. Rose, and C. H. Bayley. *Canad J. Res.*, 1950, **28F**, 213.—The paper describes investigations carried out to determine the ability of soaps in preventing the deposition of carbon black and other materials on fabrics during detergent process. Generally, suspending power of soap solutions increases rapidly with increasing soap conc, and a max is reached at a relatively low conc. Only minor differences noted between the powers of sodium myristate, palmitate, stearate, those all higher than laurate. Temp (range 25–80%) had no effect on the power of sodium oleate. A. D.

2503. Analysis and characterisation of pure compounds and mixtures of compounds. W. Reeve and R. Adams. *Anal. Chem.*, 1950, **22**, 755–9.—The temp at which a solid dissolves in a given amount of solvent is a characteristic property of the solid, and has been named the "solubility temperature" when it is determined under described

conditions. Like melting points, solubility temperatures can be used to characterize compounds, as a criteria to purity, and to analyse mixtures. They are especially useful with solids which have unsatisfactory melting points due to decomposition. A convenient procedure for rapidly and accurately determining solubility temp is described, and their usefulness in the characterization and analysis of amino acids is illustrated. J. S.

2504. Determination of traces of sulphur in organic compounds. R. E. Holeton and A. L. Linch. *Anal. Chem.*, 1950, **22**, 819–22.—Improvements in the method for the determination of 1–200 p.p.m. of sulphur in organic compounds by combustion with excess of air in a heated tube have provided a satisfactory means for the analysis of solids and liquids which are difficult to analyse by conventional methods.

The principle of the method is well established, but the design of an atomizer to deliver the sample as a fine spray in a stream of air to the combustion zone at an easily controlled rate and improvement in the absorption of sulphur dioxide and nephelometric determination of sulphur as barium sulphate permit wider applications of this principle. Better absorption of oxides of sulphur has been obtained by condensing water from the combustion in a chilled trap containing sodium perborate solution before passing the gases through absorbers. Precipitation from ammonical solution in the presence of gum arabic as a stabilizer improved the stability of the barium sulphate colloid. Accuracy of the order of 5–10% of the amount of sulphur present and a precision of ± 2 parts in the range 2–100 p.p.m. of sulphur have been attained both for volatile and non-volatile sulphur sources. J. S.

2505. Streak reagents for chromatography. A. L. Le Rosen, P. H. Monaghan, C. A. Rivet, E. D. Smith, and M. A. Suter. *Anal. Chem.*, 1950, **22**, 809–11.—A number of streak reagents, used in detecting zones of colourless substances on the chromatographic column, have been studied in regard to their usefulness in the detection of certain compounds. These reagents are all sensitive at concentrations of 0·01M. Several new streak reagents have been developed. J. S.

2506. Conversion of refractive dispersions to other wave-length intervals. A. Sankin, C. C. Martin, and M. R. Lipkin. *Anal. Chem.*, 1950, **22**, 643–9.—A general relationship of the form $(n_x - n_y) \times 10^4\ K(n_u - n_v) \times 10^4 + K'$, where n_x, n_y, n_u, and n_v are refractive indexes of a simple liquid at four different wavelengths, has been found to apply to liquids having F–C dispersions less than 250. This linear equation may be used for calculating one dispersion from another for both hydrocarbon and non-hydrocarbon liquids with an average deviation of two units of dispersion. The parameters, K and K', in the above equation are calculated from: $K = (V_x^3 - V_y^3)/(V_u^3 - V_v^3)$ and $K' = C_2 x\ 10^4[V_x^3 - V_y^3 - K(V_u^3 - V_v^3)]$, in which V is defined as the reciprocal of the wavelength. Satisfactory agreement with most data is obtained by considering C_2 to be the same for all liquids having F–C dispersions less than 250. The above expressions have been derived from the refractive index–wavelength equation $n = C_1 + C_2 V^2 + C_3 V^3$, in which the appearance of V^3 has been empirically verified, although it seems to disagree with generally accepted dispersion theory. J. S.

2507. Comparison of melting point methods for wax. A. W. Marshall. *Anal. Chem.*, 1950, **22**, 842–4.—Comparison of the melting-point methods for wax shows that there are three critical points near the transition point from solid to liquid wax. The first is the thaw point or the eutectic temp of the wax, and this is approximated by the ring-and-plunger method. The second is the melt point or the point at which all wax is actually liquid, best evaluated by the A.S.T.M. paraffin melting point for all waxes. The third is the flow point or the point at which the viscosity is reduced to about 50 cs best evaluated by the A.S.T.M. Petrolatum Melting Point method. High-melting, hard crystalline waxes are subject to viscosity hystersis at the m.p., but other petroleum waxes are not. J. S.

2508. Wax wear resistance. B. Cummings. *Soap Sanitary Chem.*, Aug. 1950, **26** (8), 114.—The use of radioactive isotopes for industrial research is rapidly becoming popular, and they are allowing accurate measurement of properties which hitherto could only be very approx determined.

In the investigation of the wear resistance of floor wax, measurements by optical and mechanical means are not sufficiently sensitive to indicate the amount of wear which occurs between commencement of abrasion and the instant when a polishing action, accompanied by negligible wear, sets in. This difficulty is overcome by dispersing a quantity of radioactive cobalt sulphate in the wax under test. Then the amount of wear, which is directly proportional to the amount of wax removed by abrasion, can be estimated by determining the intensity of radiation with a Geiger–Müller counter at selected instants during the test. O. M.

2509. The microwave absorption spectrum of methyl alcohol. B. M. Girdwood. *Canad. J. Res.*, 1950, **28A**, 180.—The microwave absorption spectrum of methyl alcohol was studied in the range 23,400–25,200 Mc using a double modulation system in which usual radio-frequency sine wave was replaced by a sharp pip-shaped pulse with a repetition rate of 55 kc. Twenty-five new lines were found, and these along with others previously reported outside the region examined were grouped into two series. An explanation of the spectrum is that it is due to rotation of two molecules joined together by the OH radical. When the methyl alcohol was mixed with a large % of water vapour the spectrum was modified considerably. The shift of the lines from their former positions and the presence of two single lines in the same region were the main features of this spectrum. A. D.

2510. Spectroscopy expands usefulness to oil industry. G. Weber. *Oil Gas J.*, 17.8.50, **49** (15), 110.—Ten different fields or methods of spectroscopy in practical use or in development stages promising commercial application are discussed. They include emission spectroscopy, ultra-violet and infra-red absorption, X-ray spectroscopy, mass spectrometry, Raman, neutron, and micro-wave spectrometry.

Other techniques involve radio-frequency spectroscopy, and analysis of samples by their fluorescence when exposed to X-rays. G. A. C.

2511. Recording double-beam infra-red spectrophotometer. I. A. Brownlie. *J. sci. Instrum.*, 1950, **27** (8), 215.—A recording infra-red spectrophotometer is described which, by the automatic balancing of two beams of radiation from the same source, is designed to eliminate variations in the spectrum caused by atmospheric absorption changes in source-radiation intensity, and drifts in the electronic amplification. The infra-red absorption spectrum of any chemical compound can thus be recorded directly as percentage of radiation absorbed versus wavelength. If in solution, the solvent can be placed in the other beam, and the absorption due to the compound alone can thus be ascertained. The spectral region covered is from 2 to 16μ, and recording time is from 12 min upwards. General details of the optical, mechanical, and electronic construction are given. C. N. T.

2512. A liquid level gauge. E. W. R. Little. *J. sci. Instrum.*, 1950, **27** (8), 223.—A depth gauge operated by a continuous air purge is described. A reference surface of a liquid is maintained at a known level by making it one boundary of a variable-area orifice and controlling the pressure differential across the orifice. The static pressure in the system is then a measure of the head of liquid in a vessel above the reference surface. C. N. T.

2513. Identification of Pennsylvania oils. W. C. McCrone. *Producers' Monthly*, Mar. 1949, **13** (5), 25.—The importance of being able to trace the origin of certain petroleum derivatives is stressed.

Short descriptions are given of the instruments used in the identification of oils. These instruments include the infra-red spectrometer, the polarimeter, the refractometer, and the density balance. The determination of bromine number and its relation to the absorbance value of an oil are also explained.

Graphs illustrate the principle of identification. A. J. H.

2514. Peet-Grady method. Anon. *Soap Sanitary Chem.*, 1950 Blue Book, 219.—A full description of the official Peet-Grady method for evaluation of insecticides which has been adopted by the Chemical Specialities Manufacturers Association of America. O. M.

2515. A.S.T.M. and I.P. co-operation in international standardization. H. Hyams. *I.P. Review*, 1950, **4**, 265.—Standardization is often decried, but it confers many benefits such as interchangeability, low cost, safety, universality, etc. This is of paramount importance in the testing of petroleum products by the test methods laid down in the U.K. by the Institute of Petroleum (I.P.) and in the U.S. by the American Society for Testing Materials (A.S.T.M.). This is the aspect described in detail of a much more complicated problem, which is mentioned superficially and which involves the relationship with the respective Standards institutes. There has been a large amount of co-operation between the A.S.T.M. and the I.P., but there is room for much more. The I.P. Method Book now refers to the A.S.T.M. method which it approaches, but the converse is not always the case. The differences between standard methods of testing are illustrated, particularly by reference to the Ramsbottom Carbon Residue, Distillation, Oxidation Stability of Motor Fuel, and Absolute Viscosity. R.H.

Crude Oil

2516. Effect of temperature and pressure on crude oil gravities. R. L. Huntington. *Oil Gas J.*, 31.8.50, **49** (17), 58.—A typical Mid-Continent oilfield has been studied to obtain data on the effect of temp and pressure on the A.P.I. gravity of the crude from that area.

Figures show effect of seasonal atm temp changes on the gravity of untreated and emulsion-treated crude oil, and a table gives stock tank temperatures and A.P.I. gravities on four representative cases where crude-oil emulsions are treated. G. A. C.

2517. Refining properties of new crudes. Part I—Significance and interpretation of Bureau of Mines routine crude-oil analysis. N. A. C. Smith, H. M. Smith, and C. M. McKinney. *Petrol. Process.*, 1950, **5** (6), 609–14.—The first part of a series, designed to acquaint refiners with the nature and characteristics of the crudes from the oilfields discovered in the states over the last few years, presents data obtained by analytical distillation and specific tests on a sample of crude oil, and discusses methods of comparison with other crudes. Curves of the vol-% and A.P.I. gravity–fraction type obtained from Bureau of Mines routine analytical distillation may be used for comparing crude oils, but for this purpose correlation index (C.I.) curves are more useful. The C.I. curve is inherently based upon the sp. gr. and b.p. of the hydrocarbons comprising each distillate fraction and offers an approx composition or possible use of each fraction. Four light crude oils are compared on this basis with the sample oil, and the possible use of the fractions of the sample oil are discussed together with the other properties normally determined. D. W. F.

Engine Fuels

2518. Improved method devised to estimate cetane number of diesel fuels. Anon. *Petrol. Process.*, 1950, **5** (6), 625–6. (*Condensed from the paper "Methods for estimating cetane number" presented by H. D. Young at the 15th Mid-Year Meeting of the A.P.I. Division of Refining, Cleveland, May* 4.)—Cetane No. estimation is further facilitated by the development of the C.F.R. Calculated Cetane Index. Being a modification of the Calculated C.No. method it is also based on fuel A.P.I. gravity and mid b.p. It is not suitable for hydrocarbons, synthetic, alkylate, or coal-tar fuels. Accuracy expected ± 2 C.No. for 75% of the fuels in the 40–60 C.No. range; ± 4 C.No. for 50% of the fuels above 60 C.No. A nomograph is presented. D. W. F.

2519. Sulphur content of diesel fuels. E. W. Steinitz. *Petroleum*, Aug. 1950, **13** (8), 200–1.—Recent troubles concerning diesel engines have been related to rising sulphur content of the fuel. No interference has been observed in slow-running marine diesels. Faster land-based stationary engines and engines of road-transport vehicles, however, have shown such troubles not only due to sulphur, but also to the lowering of ignition properties of the fuel.

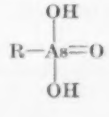
Fuel additivies are discussed, and it is stated that colloidal copper in minute quantities can remove harmful sulphur compounds. A special additive for diesel fuel should contain a lubricant and a detergent to keep the engine clean, as well as the copper. Tests with such an additive appear very satisfactory. R. E. P.

2520. Oxidation, ignition and detonation of fuel vapours and gases. XIII. The 12 : 1 compression ratio performance of the C.F.R. spark ignition engine using town gas ; comparison with diesel engines. R. O. King, E. J. Durand, B. D. Wood, and A. B. Allan. *Canad. J. Res.*, 1950, **28F**, 134.—Describes experiments which are part of a series to determine factors which limit the power and efficiency of an Otto-cycle spark-ignition engine using Toronto town gas nearly free of sulphur. Average % composition of this gas by vol is H_2 48, CO 22, CH_4 12, other hydrocarbons 6, N_2 and CO_2 12. The power was varied by varying the gas supply—air supply being unthrottled. The experiments were concerned with three principal features. (1) Performance in respect of power and thermal efficiency ; (2) effect of mixture strength on thermal efficiency and the attainable degree of quality control ; (3) performance of the spark ignition Otto-cycle engine relative to that of the compression-ignition diesel type. Trials were run using four jacket coolant temp, C.R. always 12 : 1, and the speed 900 r.p.m. Max thermal efficiency of 43% was attained at the two lower coolant temp and air–gas ratio of 8 : 1. This value decreased rapidly as air to gas was increased. The author states that performance of the Otto-cycle engine could probably be improved by running at higher speeds, but even at the relatively low speed of 900 r.p.m. for that type it compared favourably in most respects with that of the C.I. type of diesel engine. A. D.

2521. Oxidation, ignition and detonation of fuel vapours and gases. XIV. The cause of the effect of hydrogen sulphide to reduce the compression ratios at which fuel gases can be used in spark-ignition engines. R. O. King, E. J. Durand, B. D. Wood, and A. B. Allan. *Canad. J. Res.*, 1950, **28F**, 166.—This paper gives results for trials at 800 r.p.m. and 12 : 1 C.R. on Toronto town gas alone and with hydrogen sulphide added. The sulphide led to very severe pre-ignition. Interpreting results in the light of combustion-tube experiments, the author states that hydrogen in mixtures with air is not ignited by red-hot surfaces on which it is oxidized rapidly to steam, but ignition occurs at relatively lower temp if the surface reaction is inhibited by H_2S. Fuel gases containing H_2S in large proportions can be used for full-power engine operations at C.R.s $>12 : 1$ if the oxidation of the hydrogen in part to steam on the hot surfaces in the combustion chamber is not inhibited by the poisoning effect of the H_2S commonly present in the gases. A. D.

2522. Oxidation, ignition and detonation of fuel vapours and gases. XV. Concentration of finely-divided carbon in town gas–air mixtures required to induce severe knocking combustion. R. O. King, E. J. Durand, and A. B. Allan. *Canad. J. Res.*, 1950, **28F**, 177.—The experiments described were made in an investigation of the factors which have prevented the use of fuel gases in Otto spark-cycle engines at other than economically low C.R. They deal especially with nuclear ignition. If hydrogen was gaseous fuel in the C.F.R. engine, the lubricating oil decomposed to finely divided carbon when optimum spark advance nearly zero. With town gas, optimum spark advance wavered from 85° to 15° crank angle and lubricant yielded carbon of hard, adherent graphitic variety. Using L-head engine with a combustion chamber of large surface–vol ratio and spark head so placed that optimum spark advance for town gas was ½ (approx) that required with C.F.R. engine, no carbon deposit obtained. Conditions such that knocking combustion observed on adding finely divided carbon to gas–air mixture not caused to any degree by carbon from lubricant. Hence found, on adding graphite dust at measured rate to entering mixture, that 0·3 mg approx in the end gas caused a knock intensity of degree required to reduce b.h.p. by 10–14%. A. D.

2523. Patent. T. B. Tom, assr to Standard Oil Co., Indiana. U.S.P. 2,506,847, 9.5.50. A stabilized hydrocarbon motor fuel containing from about 0·005–0·5% of an organo arsonic acid having the general formula :—



C. F. S.

Lubricants

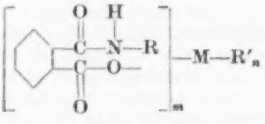
2524. Patents. E. C. Hughes and J. D. Bartleson, assrs to Standard Oil Co., Ohio. U.S.P. 2,506,597, 9.5.50. A lubricant comprising an oil-dispersible reaction product of a saturated aliphatic ketone with a sulphide of phosphorus subjected at one stage during its manufacture to at least 400° F up to 600° F to effect decomposition of the reaction product, and reacting with an element of the sulphur family at a temperature from 100° to 500° F.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,506,901, 9.5.50. Addition agents for mineral lubricating oils and compositions containing the same.

H. G. Smith and T. L. Cantrell, assrs to Gulf Oil Corpn. U.S.P. 2,506,905, 9.5.50. A stabilized lubricating grease composition comprising mineral lubricating oil thickened by a soap and a small quantity of a fatty mono-carboxylic acid ester of a fusible, soluble mono-alkylated phenol-formaldehyde condensation product.

H. G. Smith and T. L. Cantrell, assrs to Gulf Oil Corpn. U.S.P. 2,506,906, 9.5.50. A grease composition comprising mineral lubricating oil thickened by a soap and a small amount of a condensation product of formaldehyde and a higher fatty mono-carboxylic acid ester of a mono-alkylated phenol.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,507,055, 9.5.50. An addition agent for mineral oils comprising a corrosion-inhibiting compound having the formula :—



R. L. Heinrich and H. G. Schutze, assrs to Standard Oil Development Co. U.S.P. 2,507,103, 9.5.50. A method of producing lubricating oil from contaminated naphtha. C. F. S.

Bitumen, Asphalt, and Tar

2525. Geophysical methods of subsurface exploration in highway construction. R. W. Moore. *Public Roads*, Aug. 1950, **26** (3), 49.—The Physical Research Branch of the Bureau of Public Roads in America has studied the application of geophysical methods of subsurface exploration to highway work. They have found that earth-resistivity and refraction seismic tests are well adapted to road construction problems. They have established both methods as useful, rapid, and economical ways of obtaining preliminary information about the depth and nature of subsurface formations. The theory of the two methods is reviewed and some actual results discussed. These results show that the earth-resistivity test is more generally applicable to highway construction problems than is the refraction seismic test. Detailed subsurface surveys are best made by using the resistivity equipment in the first instance, checking with the seismic apparatus if necessary. The fundamental principles of the two methods differ widely, and so concordant results from the two can be accepted with confidence. R. H.

2526. Patent. G. H. Von Fuchs and N. B. Wilson, assrs to Shell Development Co. U.S.P. 2,507,070, 9.5.50. A bituminous composition, having improved hardening resistance comprising asphalt containing at least $\frac{1}{10}$% by weight based on the asphalt of an oxide of the group selenium oxide and tellurium oxide. C. F. S.

Derived Chemical Products

2527. Ethylene oxide. R. F. Messing. *Chem. Ind.*, July 1950, **66** (7), 41.—Production capacity for ethylene oxide is currently increasing more rapidly than for any other tonnage chemical.

The methods for manufacture of this product are the chlorhydrin process and the catalytic oxidation of ethylene. The former can use a less pure feedstock and, other things, such as availability of feedstock, etc., being equal, it is the more economic.

The main end uses for ethylene oxide are in the production of ethylene glycol, acrylonitrile and acrylic acid, polyglycols, non-ionic detergents in which ethylene oxide is condensed with phenol, etc., and alkylo-amines. Speciality uses are exemplified by its use in the manufacture of diethylene glycol ethers, which are excellent high-boiling solvents. O. M.

2528. Petroleum-chemicals reviewed. R. F. Goldstein. *Petrol. Times*, 1950, **54** (1386), 639.—A summary of the American chemical industry and its immediate future plans, with special reference to fine chemicals and industrial chemicals, is attempted on the basis of recent American publications and reports. Comparisons are given of the total production of various chemicals in America and in the U.K. and estimates presented of the possible production of chemical products in the U.S.A. in the year A.D. 2000. Increasing production of chemicals from petroleum is prophesied and much interesting statistical data presented. The production and technical applications of benzene, particularly in the field of polymers, receives special attention. A brief review is given of new developments in chemical manufacture such as the production of primary alcohols direct from synthesis gas by the " Osyl " process, and the Shell process for manufacture of acrolein by the catalytic oxidation of propylene.

An indication of the scope of the newer chemical industry based on petroleum is given by the reference to the twelve-stage synthesis by the Carbide and Carbon Chemicals Corporation of allethrin, a lower homologue of pyrethrin. Two key raw materials in the synthesis of allethrin, allyl chloride and methallyl chloride, are both petroleum chemicals. J. H. P.

2529. Patents. H. L. Johnson and A. P. Stuart, assrs to Sun Oil Co. U.S.P. 2,507,471, 9.5.50. Thiocyanated reaction product obtained by causing ethylene chlorohydrin to interact with 4-vinyl*cyclo*hexene and treating the product with an alkali-metal thiocyanate in the presence of metallic copper catalyst.

H. L. Johnson and A. P. Stuart, assrs to Sun Oil Co. U.S.P. 2,507,472, 9.5.50. The thiocyanate derived from 4-vinyl*cyclo*hexene by esterifying with monochloroacetic acid and an acid-type catalyst, reacting the ester product with an alkali-metal thiocyanate in the presence of a solvent. C. F. S.

Coal, Shale, and Peat

2530. Effect of humidity on absorption of methane by coal. I. L. Ettinger and G. D. Lidin. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1950, 1198–203.—Absorption of CH_4 (at 77–920 mm and 25°–30° C) was measured on three coals that had been dried (60° C, 10^{-4} mm) and then progressively humidified to a max H_2O content of 2–2·8%. Absorbed water decreases CH_4 uptake by up to 50%, effect of first traces (up to approx $\frac{1}{4}$%) of adsorbed H_2O being proportionately greater than that of larger quantities of H_2O subsequently condensed in the capillaries of the coal. V. B.

2531. Shale oil progress. Anon. *Petroleum*, July 1950, **13** (7), 173–4.—Outlines very briefly the history of Scottish development from the times of Dr James Young and the position of the industry in America. The industry is at present contained within sharply circumscribed markets, and it is concluded that intensive exploitation of oil shale is unlikely. R. E. P.

Miscellaneous Products

2532. High polymers from petroleum (1). W. Davey. *Petroleum*, June 1950, **13** (6), 137–42.—Petroleum is one of the most valuable sources of raw materials for the manufacture of a very wide range of synthetic polymers. The general nature of high polymers, the processes by which they are formed, and the nature of the reactions

involved are briefly outlined. Production of the raw materials from petroleum and their conversion into polymers is considered, the main source of the raw materials being natural and cracked gases.

Important polymers from individual compounds are discussed under each hydrocarbon or group and the products and processes summarized in the form of charts and flow sheets. Products from methane, acetylene, ethane, ethylene, propane, and propylene are outlined in the paper. R. E. P.

2533. High polymers from petroleum (2). W. Davey. *Petroleum*, July 1950, **13** (7), 171–2.—Second part of a paper outlines products from butanes and butylenes, with special reference to butadiene, which is important in the manufacture of synthetic rubbers, and products from higher paraffins and olefins. In the latter section the manufacture of phenols from *n*-hexane, etc., is outlined with the subsequent formation of phenol–aldehyde resins. It shows how the functionality of phenol determines the physical properties of these resins. Other products mentioned include aniline giving aniline–aldehyde resins and adipic acid used in the manufacture of polyesters, polymides (nylons), and polyurethanes (Perlon). R. E. P.

2534. Styrene.—A historical survey. Part 3. 1940–1949. F. Armitage. *Paint Mnfr.*, Sept. 1950, **20** (9), 313.—The manufacture of styrene is briefly discussed. A variety of methyl-substituted styrenes have been the subjects of much patent literature. In America batch mass polymerization has been mainly used, whereas emulsion and continuous methods were general in Russia and Germany. In order to regulate the speed of polymerization of styrene and the mol. wts. formed, it is sometimes desirable to carry out the process in solvent which may or may not be a solvent for the polymer formed.

For the commercial polymerization of butadiene and styrene in emulsion, some additive materials are essential, these include : emulsifying agent, catalyst, modifier, emulsion stabilizer, surface-tension regulator, and a pH adjuster or buffer. The co-polymerization of maleic anhydride with styrene, α-methyl styrene, and α-*p*-dimethyl-styrene has been studied. Methods of preparing contact resins and the development of impregnating varnishes by the co-polymerization of styrene with the half ester of maleic anhydride and castor oil are discussed. The co-polymerization of styrene with glyceridic oils, polyhydric alcoholic mixed esters, rosin, etc., is also considered. U.S. developments were concentrated on the solventless process, and α-methyl styrene was used with styrene in order to produce compatible products. Fifty-five literature references. D. K.

2535. Composition of properties of plasticized polyvinyl chloride. E. A. J. Mol. *Ingenieur*, 18.8.50, **62** (33), Mk. 71.—The consumption of plasticized polyvinyl chloride has increased enormously, especially after World War II. P.V.C. has gained an important position as a highly valued synthetic material.

The plasticizer, added in quantities of 30–70%, determines the properties of the product to a high degree. A number of the more important properties of plasticizers and plasticized polyvinyl chloride is discussed, including their mutual relation. Specific attention is paid to : the compatability and solvent power of plasticizers in relation to their polarity ; the permanence and volatility of the plasticizers connected with the resistance against ageing of P.V.C. compounds ; the effectivity ; the toxicity, in particular that of tricresyl phosphate ; the migration which often appears when P.V.C. compounds are in contact with other plastics and which can be conquered by incorporation of so-called polymeric plasticizers, which also confer good oil resistance to the final material ; the mechanical properties, as these are influenced by the viscosity and the viscosity index of the plasticizer, and the remarkable effect of time on the mechanical properties as measured with conventional apparatus. Furthermore, attention is drawn to the important influence of only a small percentage of crystallites on the mechanical properties of plasticized P.V.C. and to the effects accompanying the internal plasticization by co-polymerization. Further development will most probably go in the direction of polymeric plasticizers. These latter combine in themselves the advantages of low volatility (high permanence), low migrative tendency, and good oil resistance. R. R.

2536. Blistering of paint films. Part I. Blistering in the absence of corrosion. J. E. O. Mayne. *J. Oil Col. Chem. Assoc.*, July 1950, **33** (361), 312.—The blistering of films of unpigmented plasticized polystyrene, applied to glass, when immersed in distilled water or natural seawater was examined.

The experimental work carried out is described. It was found that blistering increased with the time of immersion, decreased as the osmotic pressure of the solution was raised, and was affected by the supporting material. It was also observed that the blisters produced under the conditions investigated, contain no liquid, thus the effect cannot be attributed directly to osmotic transfer of water through the film. It is suggested that the blisters are due to stresses associated with the absorption of water by the film, that is that blistering is controlled by the absorption of water and its cohesion and adhesion to the supporting material. D. K.

2537. Modification of alkyd resins. R. S. Robinson. *J. Oil Col. Chem. Assoc.*, Aug. 1950, **33** (362), 353.—Modifications made to alkyd resins are described. These are considered as two broad classes, namely substitution modifications and those made by additive reactions. Types of modification and the methods by which they are effected are described. In this paper glyceryl phthalate is taken as the starting point from which all modern alkyds have been evolved. The simplest modification is the replacement of the glycerol and phthalic anhydride partially or wholly by other alcohols or acids respectively. Substitution of the acidic and alcoholic reactants is discussed in some detail.

There are two main classes of compound used as additive reagents, these are phenol-formaldehyde resins and vinyl compounds.

Modifications involving the introduction of nitrogen into the molecule produce either an amido linkage or a urethane group. There are twenty literature references. D. K.

2538. Compatibility of varnish-making resins 2. H. W. Chatfield. *Paint Mnfr*, Sept. 1950, **20** (9), 327.—The author's procedure for testing the compatibility of varnish-making resins with various drying oils is described. All tests must be developed to include an ageing period. Oil lengths must be long enough to embrace all types of varnish or media which are made commercially. The degree of polymerization of oil chosen for tests must be such as to accommodate most applications of the resins with some margin of safety. Tests should be conducted with oils of different chemical constitution. Oil–resin compatibility tests should be so designed that they assess the tolerance of oil–resin mixtures for white spirit.

The most severe compatibility test should be carried out first. It consists in adding a substantial amount of cold stand oil (linseed stand oil 40 poise approx) to a cold concentrated solution of resin in white oil. One portion of this is allowed to age for seven days. To the other portion a further quantity of white spirit is added and the stage at which the mix becomes cloudy is observed; if it remains clear it is allowed to stand for seven days. This mixture is further diluted, and the stage at which it becomes cloudy again noted. If the resin under examination will not tolerate addition of stand oil in the cold to give a stable mix on ageing, solubility tests should be conducted. These are described. The precise test procedure and modified processes are given. The compatibility of resins with tung oil is also discussed.

Results of compatibility tests conducted on a number of proprietary types of modified phenolic resins with linseed stand oil are listed. D. K.

2539. Problems and methods of analytical chemistry in the field of organic coating materials. C. P. A. Kappelmeier. *Paint Technol.*, Aug. 1950, **15** (176), 337.—Article is text of paper read before Section for Analytical Science of Danish Chemical Union in Copenhagen and Swedish Synthetic Resin Union in Göteborg, September 1948. Reference is not made to usual methods, now standardized, for analytical testing of raw materials used in paint and varnish industry, nor to physical methods such as ultra-violet and infra-red spectroscopy, chromatography, etc. During past twenty-five years paint industry has become one of the most important branches of applied chemistry and physics of "synthetics," and a knowledge of properties and applications of synthetic resins is necessary to varnish and paint chemists. Chemical analysis is necessary, since as much as possible should be known of nature and com-

position of raw materials used, details of which, particularly in cases of phenolic and alkyd resins, have frequently been witheld by manufacturers. Author discusses direct value of analysis in varnish and paint industries, and puts forward a case for a central chemical department in the factory, both for research on raw materials and for examination of finished products. Analysis of finished compositions is reviewed, and general rules for separation of pigmented compositions, unpigmented varnishes, and emulsions are presented. Examples are given of recent methods for identification of following: urea, thiourea, urethane, and malamine resins; polyamides; sulphonamide resins; urethane oils. Using these methods it is possible to identify definitely all nitrogen-containing synthetic resins likely to be used in preparation of paints and varnishes. Control of procedures for preparation of important raw materials is another field of application for analysis, and illustrations are given, from author's experience, of work on dehydration of castor oil, addition of maleic anhydride to a drying oil, estimation of anhydride groups in addition compound, and chemical nature of oiticica oil. Twelve literature references included. U. N.

2540. Insecticide-resistant flies. R. B. March and R. L. Metcalf. *Soap Sanitary Chem.*, July 1950, **26** (7), 121.—The phenomenon of insecticide-resistant flies has now reached serious proportions, and investigation has isolated two such strains in California. They are the Bellflower, resistant to D.D.T. and related compounds, and the Pollard, resistant to other clorinated hydrocarbons as well as D.D.T. and related compounds. Studies on the cause of this phenomenon have led to the discovery that resistant flies are able to metabolize the toxic agents, and work is now in hand to discover synergists which will overcome the effect of this metabolism. In the light of information now available, various suggestions are made for the control of house flies. O. M.

2541. Aerosols. R. C. Downing. *Soap Sanitary Chem.*, July 1950, **26** (7), 114.—A two-part study of stability tests of low-pressure formulations and solubility of various old and new insecticides in propellants and auxiliary solvents is given.

Part I. Stability of aerosol compositions. Here the term stability is used to mean little or no decomposition or discoloration of the liquid and low corrosion of test pieces. The typical insecticidal formulation used for the tests contained 5% pyrethrum extract, 2% D.D.T., and 95% propellent using Freon 12 and either Freon 11 or methylene chloride. The tests were carried out at 150° F or 250° F, using steel and tinplate test pieces. Conclusions were:—

(1) Decomposition less with methylene chloride than with Freon 11.
(2) Corrosion greater with presence of methylene chloride and increased with higher contents thereof.
(3) Corrosion not dependent on concentration of Freon 11.
(4) Change in appearance of liquid seems independent of temperature or concentration of Freon 11 or methylene chloride.
(5) Steel seems slightly more resistant to corrosion by test formulation.

Part II. Insecticide solubility. Over the range −4° F to about 90° F the solubility of methoxychlor is, in general, higher than that of D.D.T. in Freon 11, Freon 12 and methylene chloride, and in binary mixtures containing these components. Solubilities of methoxychlor in alkylated naphthalenes are also reported. O. M.

2542. How sodium salts work in detergents. W. W. Niven and H. Gadberry. *Chem. Ind.*, July 1950, **66** (7), 61.—When added to detergents as builders, sodium salts confer various advantages. For instance, the sodium salts of weak inorganic acids yield alkaline aqueous solutions and thus assist in the neutralization of fatty acid soil. They also have the ability to sequester calcium and magnesium hardness in water. Their capacity for promoting solubility of many natural proteins is also important. Suspending power of a detergent solution is also enhanced by the presence of sodium salts, particularly silicates and phosphates, and, at the same time, they assist detergency by retarding disassociation and hydrolysis of soaps. Builders of this nature cause a decrease in interfacial tension. Sodium carboxymethyl cellulose is outstanding in its prevention of soil redeposition.

Examples of detergent formulations for specific purposes are given. O. M.

2543. Federal specification. Anon. *Soap Sanitary Chem.*, 1950 Blue Book, p. 199.—Describes the general requirements of the U.S. Federal Specifications Board for soap, cleaners, detergents, dish-washing compounds, polishes, floor wax, insecticides, etc. O. M.

2544. Floor wax specification. Anon. *Soap Sanitary Chem.*, 1950 Blue Book, p. 217.—Here are given the full specification and the standard methods for testing of water-emulsion floor waxes which were adopted by the Chemical Specialities Manufacturing Association of America in June 1943. O. M.

2545. Patents. H. G. Smith and T. L. Cantrell, assrs to Gulf Oil Corpn. U.S.P. 2,506,903, 9.5.50. A synthetic wax comprising a substantially neutral higher fatty monocarboxylic acid ester of a fusible, soluble mono-alkylated phenol-formaldehyde condensation product.

H. G. Smith and T. L. Cantrell, assrs to Gulf Oil Corpn. U.S.P. 2,506,904, 9.5.50. A synthetic wax comprising a substantially neutral condensation product of formaldehyde and a higher fatty monocarboxylic acid ester of a mono-alkylated phenol.

E. Lieber, assr. to Standard Oil Development Co. U.S.P. 2,507,111, 9.5.50. A high-mol.-wt. condensation product of sulphur dichloride with stearoyl phenol, having the general formula :—

$$C_{17}H_{35}CO{-}(HO)C_6H_3[-S{-}C_6H_3(OH){-}COC_{17}H_{35}]n{-}S{-}C_6H_3(OH){-}COC_{17}H_{35}$$

where n is at least one condensation product being oil-soluble and having a mol.-wt. of about 1000–3000.

S. B. Lippincott and L. A. Mikeska, assrs to Standard Oil Development Co. U.S.P. 2,507,112, 9.5.50. The preparation of *para*-quinone dioxime by forming a solution containing a hydroxylammonium salt and nitrosophenol, heating to a temp between 40° and 100° C for a period of approx 1–20 hr to effect reaction of salt with the nitrosophenol and recovering *para*-quinone dioxime as a product. C. F. S.

Corrosion

2546. Orientation of a polyfunctional organic molecule at a steel surface. N. Hackerman and E. E. Glenn, Jr. *J. Phys. & Colloid Chem.*, 1950, **54**, 497–505.—The investigation reported is part of a study of corrosion inhibition by polar organic molecules. An electron-diffraction surface-reflection technique was employed. The inhibitor was an alkyl pyrrolidine-dione of mol.-wt. *ca* 350 in solution in a mixture of *n*-hexane, 2-methyl-pentane, and 3-methyl-pentane in concn from 0·0001–1·0%. Results show that the adsorption on to a steel surface was more firm from the more dilute solutions. Gradual fading of the arc pattern was noted. The results are discussed in relation to the molecular orientation at the surface. D. F. J.

2547. Modern non-corrosive bactericidal treatment of input water. F. Latter. *Producers' Monthly*, Apr. 1949, **13** (6), 47.—The decline in the intake rate in the region of 10% has long been accepted as inevitable by operators of water-injection projects. It is stated by some authors, however, to have no theoretical justification. The decline is caused by the plugging of the sand face by micro-organisms and chemical precipitates, and is more pronounced in the tighter sands. These are the more productive sands encountered in secondary recovery projects.

The use of certain compounds, such as Pur-o-san, combine the properties of bactericides, non-corrosive inhibitors, and wetting agents. The use of Pur-o-san has been demonstrated to be effective in controlling bacteria, and in removing oxygen, this being the principal factor in the prevention of corrosion. It prevents, therefore, the deposition of particles at the sand face.

As a further property, Pur-o-san is stated to be non-toxic and non-irritating to the skin, thus making it safe for use.

The results of field and laboratory tests are given in seven tables and two graphs. A. J. H.

2548. New chemical treatment of flood water for bacteria and corrosion control. J. N. Breston. *Producers' Monthly*, May 1949, **13** (7), 16.—Extensive work on compounds suitable for bacteria and corrosion control has led to the development of alkyl and aryl high-mol.-wt. amine salts and certain condensed ethylene oxide–amine compounds which are available commercially.

Corrosion is to be avoided, not only to reduce the expense of maintaining sound equipment, but also to prevent the plugging effect of the products of corrosion on the sand face. In conducting tests on corrosion inhibitors it was noted that the bactericidal properties of many of these compounds were well developed. Subsequent investigations were made, therefore, with the aim of developing bactericide–corrosion-inhibitor properties.

Methods for testing for corrosion under static and dynamic conditions are described with the aid of diagrams. In order that the bactericides should have been thoroughly tested, contaminated field waters were used. Surface-active properties of the compounds were also investigated.

Bactericidal effectiveness was calculated on a basis of per cent kill in the cases of aerobic and anaerobic bacteria. The results show that an effective kill, at least 95%, could be obtained with concentrations below 10 p.p.m.

Twelve graphs are reproduced, in addition to tables giving more detailed information of the compounds. A. J. H.

2549. Further field test results on the use of corrosion inhibitors and bactericides for secondary recovery flood waters. E. T. Heck, J. K. Barton, and W. E. Howell. *Producers' Monthly*, May 1949, **13** (7), 27.—An extensive survey of field tests demonstrates the applicability of three suitable bactericide–corrosion inhibitors: Rosin amine D acetate, Pur-o-san, a quaternary ammonium salt, and Arquad S, a trimethyl ammonium chloride compound. Six different leases on the Bradford field were selected for the tests.

The three compounds were found to be satisfactory, Rada and Pur-o-san controlling corrosion effectively, and the former being more suitable in waters containing hydrogen sulphide. The data given include analyses of the field waters and tables of corrosion test results and bacteria counts. A. J. H.

2550. Corrosion resistant liners in refinery vessels. G. C. Carpenter. *Refiner*, 1950, **29** (7), 95–103. (*A.S.M.E. Petroleum Mech. Engng Conference, Oklahoma City, Oct.* 1949.)—A detailed consideration of the method of lining vessels with corrosion-resisting metals. Reports of hydraulic tests on several types of welding. Strip-welded liners prove to be better than plug-welded liners for economy of installation and quality. Ferrous strip liners should be butt welded, but non-ferrous liners should overlap on one or both edges to give uncontaminated welds. Stud welding indicated to have many advantages. A brief review of the applicability of various types of lining is given. R. W. G.

2551. Corrosion by leaded petrol. Anon. *Mech. World*, 1.9.50, **128** (332), 216.—Tests have been made under both constant-temp and cyclic-temp conditions to examine the process by which the products of combustion of leaded gasoline cause corrosion. Eighteen alloys were examined, and the conclusions drawn are as follows. Under cyclic-temp conditions the products of combustion of petrol treated with Ethyl fluid are corrosive from a strength point of view, *i.e.*, they behave as though they increased the effective concentration of oxygen present in the test atmosphere. High oxygen contents plus PbO produce a very corrosive condition, and temperature cycling appears to be necessary for the PbO to be most active. Long tests at constant temperature show that PbO with 3% O_2 becomes less effective in reducing the strength than air alone. Corrosion caused by combustion products of leaded fuel may be due to PbO alone, the amount depending on whether or not it is molten as well as its fusing action with the metal oxide available. $PbBr_2$ may assist the production of a liquid deposit containing PbO. A. S.

2552. Fundamentals of galvanic corrosion. A. B. Lavderbaugh. *Oil Gas J.*, 17.8.50, **49** (45), 97.—Illustrations from everyday applications in the petroleum industry of the principle of the electric-cell are given.

Fifteen diagrams show among other actions, corrosion caused by dissimilar metals, dissimilar soils, differential aeration of soil, pit action, creek and well corrosion, and use of anode to protect new and old pipe. G. A. C.

2553. Materials for use in ships' condensers and other seawater-carrying systems. P. T. Gilbert and R. May. *J. Inst. Marine Engrs.*, Aug. 1950, **62** (8), 291.—One important factor in the selection of material for ships' condensing systems and other metallic parts or pipes in contact with seawater is its corrosion resistance. Another is the working properties of the material. Incidence of corrosion depends on such things as speed of water through system, degree of contamination of water, water temp, number and size of entangled air bubbles carried by it through system, amount of turbulence and impingement produced, and formation of deposits on various metal surfaces. Types of corrosion are described under the following headings : (i) dezincification, (ii) impingement attack (or corrosion-erosion), (iii) pitting, (iv) galvanic effects and stray currents. Materials for various parts are considered from the point of view of their resistance to corrosion. For condenser tubes various brasses, copper–nickel alloys, tin and aluminium bronzes, and other materials are discussed. Ferrules, tube plates, water-boxes, cooling-water trunking, inlet and discharge tubes and boxes, auxiliary services (fire mains, plumbing systems, etc.), pumps handling seawater, and refrigerating systems are dealt with in a similar manner. A. S.

2554. Water-soluble cutting oils as pickling inhibitors. K. F. Hager and M. Rosenthal. *Oil Gas J.*, 24.8.50, **49** (16), 142.—Laboratory investigations have shown that most commercial water-soluble cutting oils are efficient inhibitors against acid attack of the base material and give a temporary protection against re-rusting to the freshly pickled, highly active, metal surface.

Tables show effect of cutting oils as inhibitors, on corrosion-retardation rate, percentage cutting oil versus corrosion rate ; and retardation in 4·9% H_2SO_4.

G. A. C.

Engines and Automotive Equipment

2555. Fuel injection for petrol engines. Anon. *Mech. World*, 8.9.50, **128** (3321), 227.—Series of experiments have been carried out to investigate claims made for improved fuel consumption and higher max power obtained by substituting petrol-injection system for a carburettor. Results have been obtained on two high-speed engines of approx 1½ litres capacity, but of widely differing characteristics, with a system which has metered fuel to the cylinders within a tolerance of ±2%. It is shown that the application of petrol injection has in each instance produced an appreciable improvement in performance. Petrol injection is unlikely to give appreciable improvement over part-throttle range if engine is capable of burning efficiently a wide range of weak mixtures. If engine is not specifically designed to operate on very weak mixtures part throttle improvement may be obtained by application of pilot injection. It will give increased power due to : (*a*) better filling due to removal of choke, re-design of manifold and absence of intake charge heating, (*b*) reduced octane requirement, (*c*) a cooler combustion chamber, (*d*) use of higher C.R. An increase of power amounting to 19% has been obtained on one engine with an increase in specific economy of 12%. Other advantages are listed. A. S.

2556. First free-piston engine installation. Anon. *Motor Ship*, Sept. 1950, **31** (368), 208.—First marine installation of free-piston engine in conjunction with gas-turbines to be made in two 850-ton cargo vessels being built in France, for shipping company of Armement Worms. Free-piston engine designed according to Pescara system and units being built at Ch. et At. Augustin Normand, Havre. In free-piston engine the two free pistons in main cylinder drive compressor pistons which supply air to combustion cylinders for scavenging and supercharging. Mixture of excess air and products of combustion passes out through exhaust ports to gas collector and thence to turbine. Bore of combustion cylinder is 340 mm and unit designed to develop 1100

b.h.p. on turbine shaft, but output limited to 800 b.h.p. in ship. Dia of complete free-piston generator is 1200 mm and length 4150 mm. There are two free-piston generators, one a spare. Electrically driven pump of 21 tons/hr capacity for fresh-water cooling of cylinders and 18 tons/hr pump for supply of lubricating oil employed. 30-ton seawater pump installed. Gas turbine runs at 9800 r.p.m., reduced to 180 r.p.m. at propeller. Weight of turbine 6·2 tons, total weight of installation with two generators 60·5 tons, compared with estimated weight of 69·5 tons of four-stroke supercharged diesel machinery of corresponding output in similar vessels. Believed that fuel consumption will be no greater than that of modern diesel-engined plant of equal capacity. Diagrams show engine-room plans of ship with free-piston generators and section through free-piston unit. U. N.

2557. Compression ratio, octane demand and lubrication. R. J. S. Pigott. *Refiner*, 1950, **29** (7), 111–14. (*A.P.I. Lubrication Committee mtng, Detroit, June* 1950.)—The automotive industry is leading to the design of engines with C.R. of 12·5 : 1. This will require an increase in octane rating of 15 over the 92–93 Research O.N. of some premium motor gasolines. Better design of engines would reduce the need for high-octane fuels and would prove cheaper than the production of extra-premium gasoline. Several improvements in design are available, and the use of better cylinder-head cooling, piston cooling, and supercharging are particularly mentioned. The degree of piston-ring lubrication is also mentioned. R. W. G.

2558. Patents. G. Sola. U.S.P. 2,507,355, 9.5.50. Fuel filter for injectors for I.C. engines.

M. Mallory. U.S.P. 2,507,415, 9.5.50. Fuel-control system for injection-type I.C. engines.

O. O. Oaks, assr to Thermal Liquids Inc. U.S.P. 2,507,643, 16.5.50. System for obtaining and maintaining operating temperatures of I.C. engines. C. F. S.

Safety Precautions

2559. Reduced hazards to personnel attained with Pure Oil's flare stack igniter. E. P. King and R. B. Paxton. *Petrol. Process.*, 1950, **5** (6), 635–6.—The ignition device used by the Pure Oil Co. consists of an electrical-resistance igniter coil placed inside a 1-inch tube at a T-junction. Natural gas mixed with air prior to reaching the T is ignited with the gas flow turned off. The gas flow is then turned on slowly so that the flame is projected to the outside of both Ts. Details of the igniter head are given.
D. W. F.

Miscellaneous

2560. The application of radioactive tracer techniques to the study of the movement of oil in sands (1). S. E. Coomber and E. N. Tiratsoo. *Petroleum*, July 1950, **13** (7), 165–70.—Read before the Institute of Petroleum, the paper describes results of preliminary experiments to investigate fluid distribution in sand, oil, and water mixtures. Radioactive tracers are used for assessing the oil and water content without disturbing the system.

The basic theory of radioactive tracer work is outlined with details of apparatus, and includes an account of some general aspects of laboratory management peculiar to the handling of radioactive substances and of the personal hazards involved.

Reasons for choosing radioactive iodine are given with a description of methods for the measurement of the absorption properties of laboratory materials. It also describes how, within limits, the oil content of a sand can be measured. Adsorption of the isotope on walls and sand is of great importance.

Experiments on oil movement and accumulation are to be described in a later issue.
R. E. P.

2561. Odour perception and combating bad odours. P. A. Van Luyt. *Ingenieur*, 1.9.50, **62** (35), G.43.—After some brief remarks on the anatomy, physiology, and pathology of the olefactory organ, the importance of smell in general and in some special cases is discussed. The effects of smell sensations on comfort and of bad odours on health are stressed. In conclusion, various means for combating odours are mentioned and the economic importance of offensive odours is referred to. R. R.

2562. Operating alternatives on basis of cost analysis. J. L. Fox. *Refiner*, 1950, **29** (7), 90–4.—Examples are given of how differential cost analysis may assist in the choice of refinery operation. Thus, a simple cost analysis can quickly indicate whether it is better to crack kerosine or sell as such, etc. However, the cost of operation is only one of the many factors influencing refinery decisions. R. W. G.

BOOKS RECEIVED

The Motor Ship Reference Book. By the staff of *The Motor Ship*. 19th edition. London: Temple Press Ltd., 1950. Pp. 187 + xliii. 15*s*. net.

For this edition the contents have been rewritten and, after a survey of developments in motor shipbuilding since the motor ship was first adopted for ocean-going tonnage in 1912, descriptions and illustrations are given of main and auxiliary engines now in established use. Information of a general nature is included and a chapter on centrifugal separators for fuel-oil treatment.

Benzole and Toluole from Coal Gas. Ministry of Fuel and Power. London: H.M. Stationery Office, 1950. Pp. 74 + 22 folded tables. 5*s*. 6*d*. net.

A report on a series of tests carried out on benzoles and benzole plants at over 300 gas-works during the period November 1941 to November 1945. The report gives a comprehensive picture of the benzole and larger carbonizing plants in the U.K. and should be of value to all fuel technologists.

Annual Reports on the Progress of Chemistry for 1949. Edited by R. S. Cahn.

Volume 46 in the Chemical Society's series of "Annual Reports on Chemistry" surveys developments during 1949 under six general headings: general and physical chemistry; crystallography (1947–8–9); inorganic chemistry; organic chemistry; biochemistry; analytical chemistry. Under each heading are included chapters on various aspects of the main subject, each prepared by an author well versed in that particular field.

S.A.E. Handbook 1950. New York: Society of Automotive Engineers Inc., 1950. Pp. 1082 + lxiv.

The official handbook of the S.A.E., containing the current standards and recommended practices of the Society. The recommendations of the Fuel and Lubricants Committee cover the classification of crankcase oil and transmission and axle lubricants. Since the 1950 edition was published the S.A.E. 70 classification has been withdrawn.

Road Research. Index of Publications of the Road Research Laboratory, 1933–1949. London: H.M. Stationery Office, 1950. Pp. 24 + iv. 1*s*. net., 1*s* 2*d*. post free.

The work of the Road Research Laboratory has been described in many publications, ranging from official reports issued by H.M. Stationery Office to papers contributed by members of the staff to learned societies and the technical Press. All are now recorded in this booklet, which includes brief summaries of the contents of the longer official reports. A comprehensive subject index of titles enables all the publications on a particular subject to be found easily.

B.S. 240: Part 2: 1950. Steel Balls for Brinell Hardness Testing. London: British Standards Institution, 1950. Pp. 7. 2*s*. net, post free.

B.S. 1553: Part 2: 1950. Graphical Symbols for Power Generating Plant. London: British Standard Institution, 1950. Pp. 17. 2*s*. 6*d*. net, post free.

B.S. 1553: Part 3: 1950. Graphical Symbols for Compressing Plant. London: British Standards Institution, 1950. Pp. 11. 2*s*. net, post free.

B.S. 1583: 1950. One-mark Bulb Pipettes. London: British Standards Institution, 1950. Pp. 11. 2*s*. net, post free.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER

NOVEMBER 1950

The following have applied for admission or transfer to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Applications for Membership

AILAWADI, Ghansham Das, service engineer, Burmah-Shell Oil Storage and Distributing Co. (*M. P. McCarthy ; J. Coates.*)

BALDWIN, John Garton MacDonald, assistant operator, Anglo-Iranian Oil Co. Ltd.

BROOKS, Douglas Gordon, senior technical engineer, Vacuum Oil Co. Ltd. (*S. L. Neppe ; P. G. Pomeroy.*)

BUREAU, Alfred Charles, manager (Gas Dept.), Messrs. Henry Balfour & Co. Ltd.

DA CUNHA BAHIANA, Jose Eduardo, chief civil engineer, Shell-Mex Brazil Ltd. (*G. C. Carr ; C. T. Wellington.*)

DARRELL, Arthur Richard, Sergeant, R.A.F. (*R. H. Vernon ; G. Reid.*)

DICKESON, Raymond Victor, production field assistant, Sarawak Oilfields Ltd. (*W. Morse ; H. W. R. Wardlaw.*)

DRYSDALE, Charles Douglas, acting chief geologist, Anglo-Ecuadorian Oilfields Ltd. (*A. J. Fincham ; P. H. de Pass.*)

EL BADRI, Ali, technical advisor, Shell Co. of Egypt Ltd. (*A. D. Coupe ; G. I. Gollin.*)

GUPTA, Rajendra Kumar, service engineer, Burmah-Shell Oil Storage and Distributing Co. Ltd. of India. (*M. P. McCarthy ; J. Coates.*)

HUNT, Albin Digby, geologist and palaeontologist, Anglo-Ecuadorian Oilfields Ltd. (*P. H. de Pass ; A. J. Fincham.*)

KING, George, supervisor, Shell-Mex Brazil Ltd. (*G. C. Carr ; C. T. Wellington.*)

ROGERS, Mechelin Joel Langley, assistant to pipeline superintendent, Kuwait Oil Co. Ltd. (*E. Boaden ; R. L. Wilson.*)

SAXENA, Soma Deva, lubricants engineer, Burmah-Shell Oil Storage & Distributing Co. of India Ltd. (*M. P. McCarthy ; J. Coates.*)

SINGH, Rajindar, service engineer, Burmah-Shell Oil Storage & Distributing Co. of India Ltd. (*M. P. McCarthy ; J. Coates.*)

VAN DER MERWE, Clemens Crispus, senior technical officer, South African Bureau of Standards.

VARCOE-COCKS, Douglas, chief engineer, Shell-Mex Brazil Ltd. (*G. C. Carr ; C. T. Wellington.*)

VENKATACHALAM, E., scientific assistant, Ordnance Fuel Testing Laboratory, Madras.

WILSON, Ian Hamilton, technical assistant, " Shell " Refining & Marketing Co. Ltd. (*H. W. Fleming ; T. T. Davies.*)

Transfers

BAND, Charles Henry, chemical engineer, Lobitos Oilfields Ltd. (*J. S. Parker ; V. Biske.*) (*Student to Associate Fellow.*)

RANKIN, Philip Alexander, production engineer, Compania Petrolera Lobitos. (*Student to Associate Member.*)

NEW MEMBERS

The following elections have been made by the Council in accordance with the By-laws.

Elections are subject to confirmation in accordance with the By-laws.

As Fellows

MALBOS, P. J. PATTIE, J. W. RYLAND, F. C.

As Members

NORMAN, J. PETERSON, A. T. WADDINGTON, C. W.

As Associate Fellows

BARTLETT, D.
BEEBE, R. D.
BOYLE, N. F.
CABOT, L. W.
CHATWIN, A. H.
COLENUTT, F. H.
DAVIES, G.
EDMINSTER, J. W.
ELPHICK, O. J.
HOGAN, W. J.
IRVING, G. A. W.
LEAHY, P. J.
MILNE, R.
REECE, H. W. W.
RUSSELL, T. W.
YULE, R.

Transferred from Student to Associate Fellow

HAMBLIN, R. J. J.

As Associate Members

COX, J. T. JACKSON, P. B.
DRIVER, R. P. LEWIS, G. K. K.

As Students

VRBA, P. WALLEN, J. I. A.

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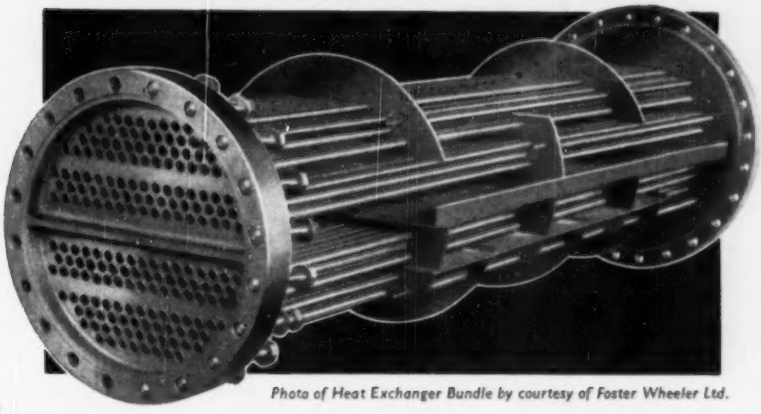

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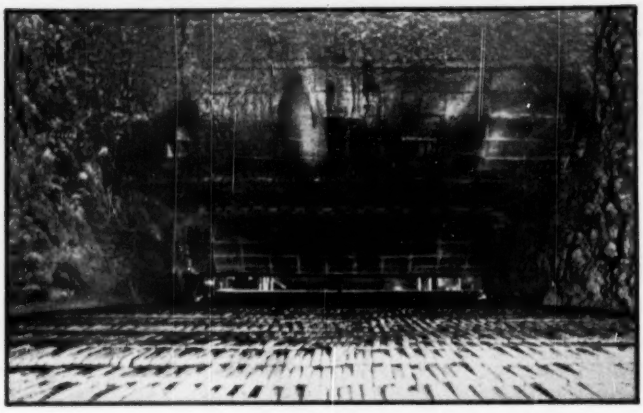

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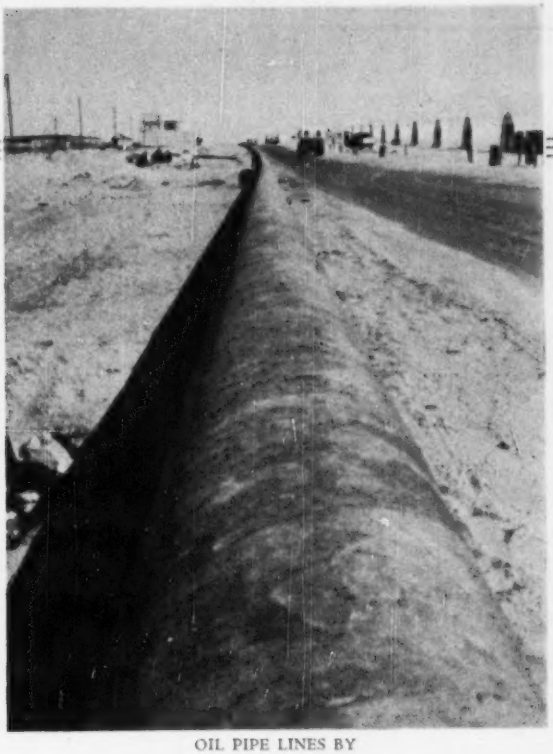

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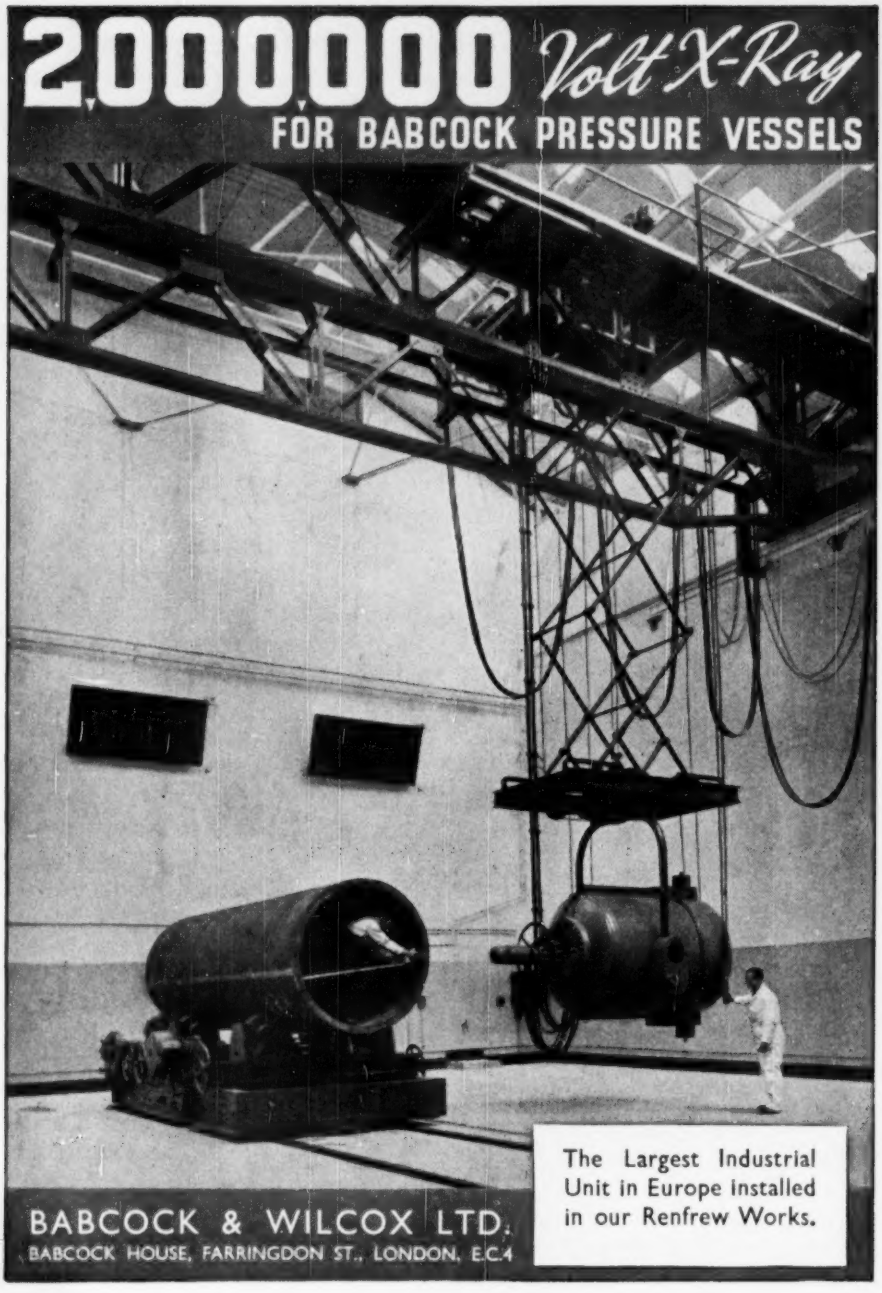
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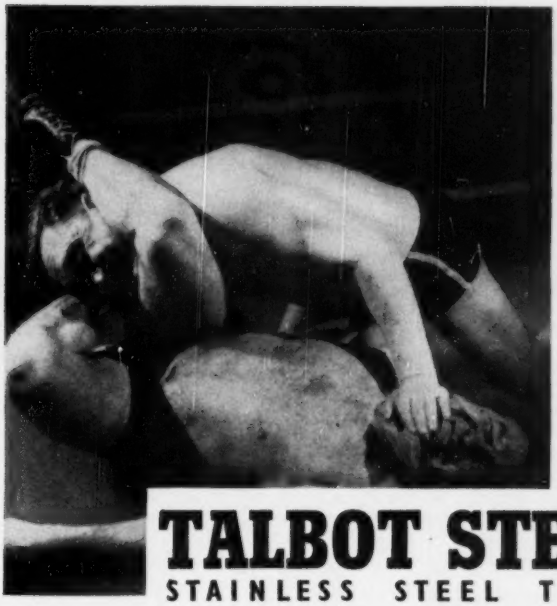

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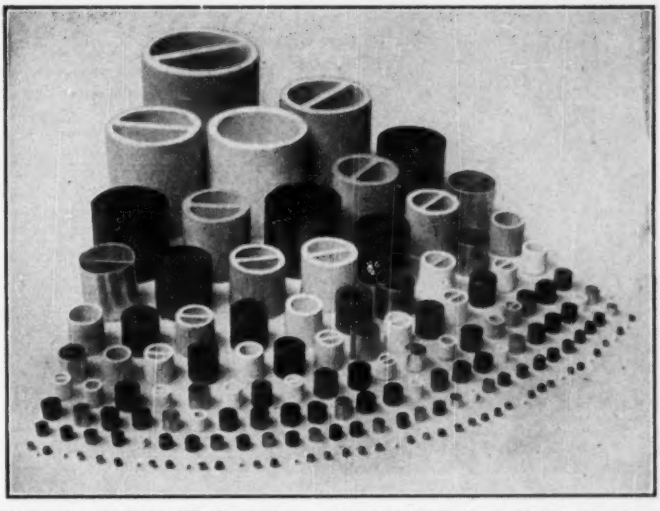

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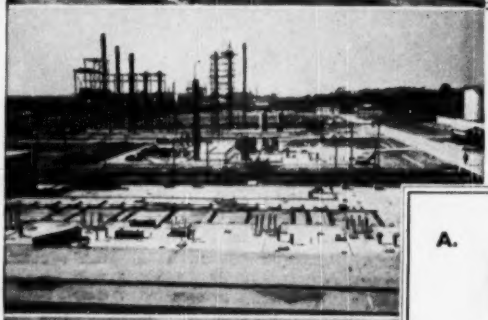

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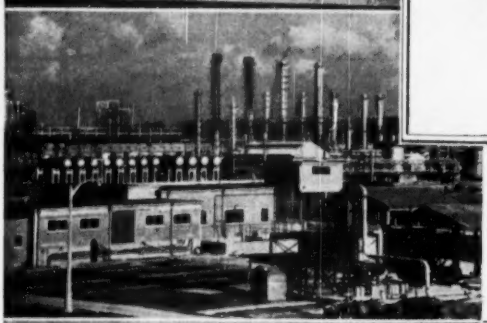

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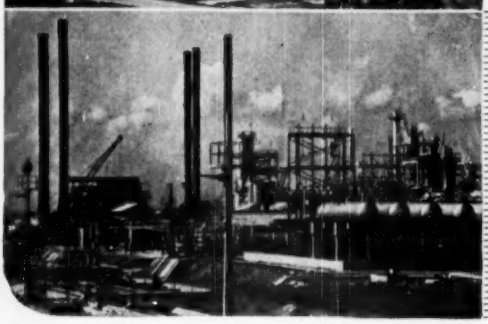

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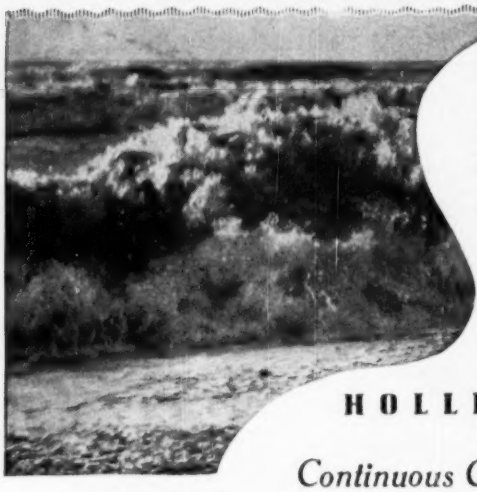

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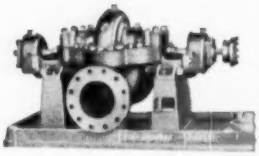
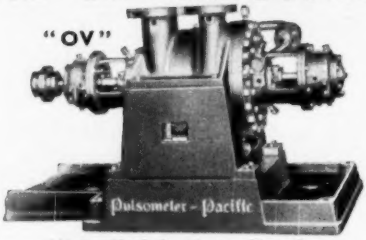
Pulsometer-Pacific

PUMPS FOR THE OIL INDUSTRY



"KH"

Horizontally Split Casing Single-Stage Hot Oil Pumps.



Vertically Split Casing Two-Stage And Three-Stage Hot Oil Pumps.

The above are some only of the Designs included.

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from "The Pipe Book" by Alfred Dunhill

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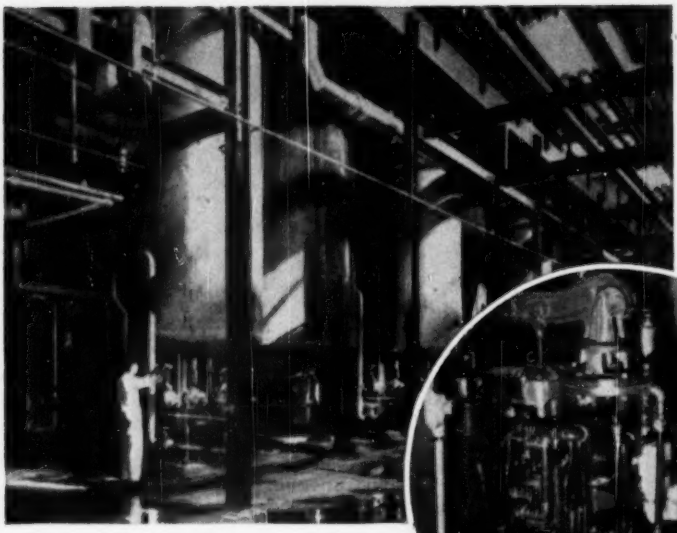
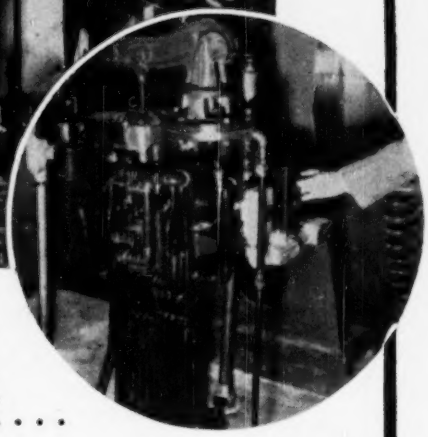
The industrial pipe does not lend itself to such ornate design; efficiency is more important. KENYON will survey your plant and put forward schemes of heat insulation representing the best balance between capital expenditure and the year-by-year saving which proper insulation ensures. Installations carried out in any part of the world.

KENYON *Planned* **HEAT INSULATION**

WILLIAM KENYON & SONS LTD., DUKINFIELD, CHESHIRE

KH 85





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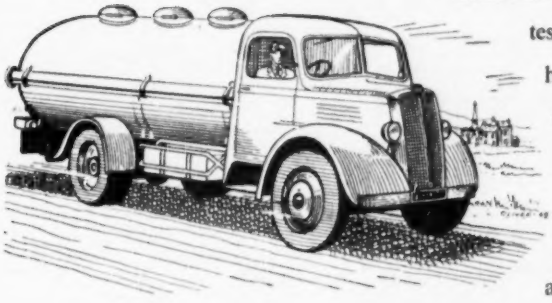

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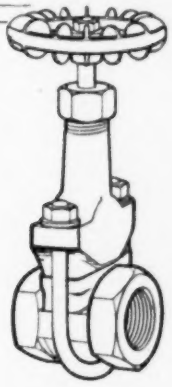

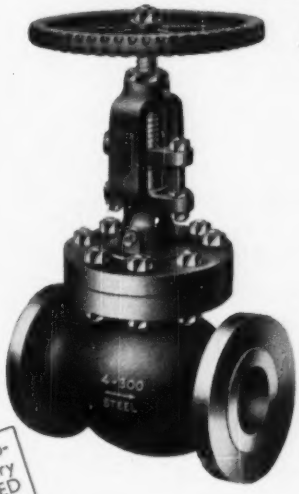

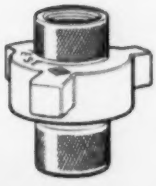

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Newman, Hender & Co. Ltd

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- VAPOUR STORAGE SYSTEMS
  In association with the *Chicago Bridge and Iron Co. Vapordome Roof tanks, Vaporspheres, Horton Lifter Roof tanks. (*Illustration shows tank 60 ft. dia. x 40 ft. high, with 38 ft. dia. Vapordome.*)*
- PRESSURE STORAGE SYSTEMS
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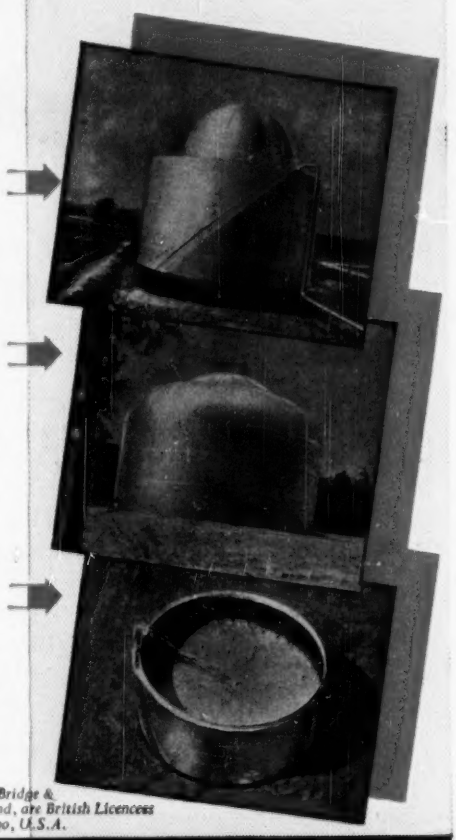

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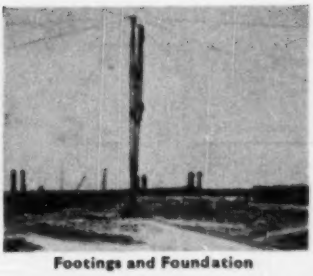
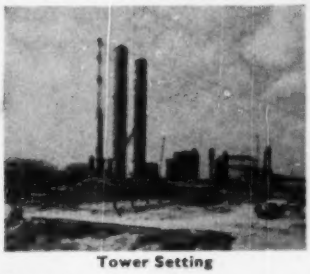
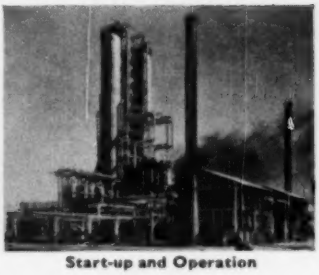


Footings and Foundation



Tower Setting



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your project

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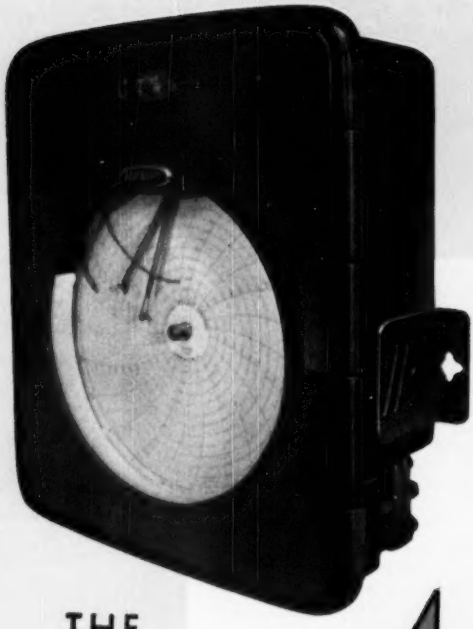

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for extremely hard and abrasive formations to overcome excessive Gauge wear.

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